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Purpose

The *Journal of Insurance Regulation* is sponsored by the National Association of Insurance Commissioners. The objectives of the NAIC in sponsoring the *Journal of Insurance Regulation* are:

1. To provide a forum for opinion and discussion on major insurance regulatory issues;
2. To provide wide distribution of rigorous, high-quality research regarding insurance regulatory issues;
3. To make state insurance departments more aware of insurance regulatory research efforts;
4. To increase the rigor, quality and quantity of the research efforts on insurance regulatory issues; and
5. To be an important force for the overall improvement of insurance regulation.

To meet these objectives, the NAIC will provide an open forum for the discussion of a broad spectrum of ideas. However, the ideas expressed in the *Journal* are not endorsed by the NAIC, the *Journal's* editorial staff, or the *Journal's* board.

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NAIC 2005 Winter National Meeting
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Public Hearing Transcript

Please Note: This transcription has been edited for length and clarity.

TIM WAGNER: Those of you who know me realize that I am passionate about the topic of global warming. We had planned to have this session at the NAIC 2005 Fall National Meeting. Mother Nature had other ideas; as a result of Hurricane Katrina, the session was postponed. We are gathered here today to discuss the implications of climate change on insurers, regulators and insurance consumers. I had a lot of help as I tried to find experts in the field of climatology and modeling to speak to us today. I would like to acknowledge Larry Shapiro from the Rockefeller Family Fund, Nancy Skinner from The Climate Group and Birny Birnbaum from the Center for Economic Justice for their energy and work putting this symposium together. Thank you very much.

We're going to lead off with comments from Larry about why we're interested in climate change. He was helpful in identifying some of the individuals and organizations that have been active in that field.

LARRY SHAPIRO: I'm Larry Shapiro from the Rockefeller Family Fund. Based in New York, we're a foundation that supports a variety of efforts on public policy issues, and we helped put together this forum. I've been doing a lot of work on insurance and climate change issues, along with Nancy Skinner from The Climate Group and Birny Birnbaum from the Center for Economic Justice, as well as Andrew Logan from Ceres and Kate Dennis from the Natural Resources Defense Council.

It's scientific consensus at this point that global warming is real. Our climate is changing. This is due to increased emissions of, especially, carbon dioxide. And, there are a variety of legitimate arguments about what should be done about it, how to do it and so on.

Many environmental organizations are concerned about global warming and how to adapt to the changes that will happen. But I think the more important topic is how to do everything we can to prevent these kinds of changes from happening in the first place. There are a lot of other groups that are interested in this topic. For example, there was recently a letter from managers of various pension funds and other money managers representing, I think, $800 billion in assets, to the leadership of the major insurance companies asking them about the nature of their financial exposure to climate change and what they're doing about it.

So, I think this shows climate change is an important issue. I first became interested in it when I was at an investor summit at the United Nations in 2003. There was a lot of discussion about what could be done, whether through shareholder resolutions or SEC rules and so on, to get major corporations to take action associated with trying to limit their emissions of carbon dioxide. It struck me in the course of that meeting that insurance companies have a special role in all of this, because insurance companies are in the business of dealing with risk

— and, certainly, global climate change is among the most risky things we can think of.

It also struck me, and a number of people who have been working on this, that unlike other industries, insurance is regulated at the state level. As somebody with a long history at the NAIC explained to me, the NAIC essentially provides a national system of regulating the insurance industry but without the actual involvement of the federal government, and that seems like an apt description in some ways of the NAIC. Because insurance regulation happens at the state level, this question of whether the insurance industry is going to remain financially healthy as it grapples with climate change, is based on whether the insurance industry — and insurance regulators — can do things differently in order to make it less likely that the climate will change as much or as fast as it might otherwise. I think that is an important question, and it's one I think insurance regulators really need to think about.

At the Rockefeller Family Fund, we're interested in seeing the NAIC's Executive (EX) Committee create a real forum for these kinds of issues to be addressed, because the climate change issue arises in relation to a wide range of different lines of insurance, it's certainly not just property and casualty. We're also interested in seeing the NAIC take a stand in suggesting to the U.S. Congress that there ought to be some system for regulating carbon emissions. So, I'm glad Tim took the leadership to set up this forum. I hope it will be useful.

TIM WAGNER: I'm certainly sorry that we weren't able to have this forum in September. In the interim, however, there was a separate forum that took place on climate change, the Connecticut Global Climate Change Summit: Business Risks and Opportunities for Connecticut's Insurance Industry. And that's the reason [Connecticut Insurance Commissioner] Sue Cogswell is here. I heard many good things about the information and the dynamics of the process of the forum held in Connecticut, so I asked Sue to give us a short report on what happened and to discuss some of the things that were addressed.

SUE COSGWELL: Thank you, Tim. Unfortunately, none of us wanted to see the Fall National Meeting canceled, but it did allow Connecticut to become the leader on this issue. We're pleased to have been able to do that. Two of today's speakers were in Connecticut with us; we also had more than 100 insurance regulators in attendance.

The Connecticut Climate Change Action Plan 2005 recommends about 55 actions to reduce state greenhouse emissions in Connecticut. Presented to the Connecticut General Assembly on February 15, 2005, the plan was developed by the Governor's Steering Committee on Climate Change with input from diverse stakeholders — including representatives of government industry, non-government organizations, academia and the public — and with the support of the General Assembly's committees on Environment, Transportation, Commerce and Energy & Technology.

The plan represents a major milestone in representing the public's concern about global warming and achieving national goals to reduce greenhouse gas

emissions. Recommendation No. 54 of the plan is a public education initiative to promote awareness and education to Connecticut citizens and businesses about solutions and the impact of global warming. One of the specific actions under this initiative is to convene a seminar or series of seminars. It was determined that we should start with the insurance industry, and I think we're going to hear today why it's important to have the insurance industry represented.

In addition to me, the forum was convened by the Connecticut Department of Environmental Protection Commissioner Gina McCarthy and Connecticut State Treasurer Denise Nappier. Our goals were to promote a general understanding of the science of climate change, and to introduce climate change business opportunities and risks to senior executives in the Connecticut insurance industry. We wanted to share views and observations from insurance and financial services industry peers, all ready to be engaged in and look at these issues. We also wanted to demonstrate the strong support and leadership of the governor's office in reviewing the impact of climate change issues and how they impact the insurance and financial services industries — as well as to gain commitments from the insurance and financial services communities on these issues.

One of the speakers we had that day was Evan Mills, who you're going to hear from today. He spoke on the science of climate change and its potential impact on the environment, the economy and society. He also introduced the link to insurance and financial services businesses and the need to mitigate and adapt, and continue efforts to reduce greenhouse emissions. He was an excellent contributor to our project.

Commissioner McCarthy talked about Connecticut's climate change action plan, and plans for legislative action in Connecticut.

Treasurer Nappier talked about the potential financial impact on publicly traded companies, and the implications for portfolio managers. She highlighted the need for active engagement by stockholders with key company industries on climate change issues.

Another speaker was Jacque Dubois, chairman and CEO of Swiss Re. Swiss Re has a number of scientists working on this particular issue. Mr. Dubois spoke on this topic at the NAIC's Commissioners Conference last February, and I think the commissioners at that presentation were quite taken by his discussion.

We also had Joseph Boren, chairman and CEO of AIG Environmental, who you're also going to hear from today. He talked about the impact of climate change on terms and conditions, product lines and national hazard modeling, as well as the need for better risk management, research and evaluation of climate change. We had a presentation by Daniel Isaac, vice president of Conning Assets Management, on carbon and clean technology funds and the need for better risk management research and evaluation of publicly traded companies.

Finally, we had a very interesting presentation from David Johnson, executive vice president and CFO of The Hartford Financial Services Group. The Hartford's experience in their part in as climate leaders in their climate leaders program. And if any of you think that CFOs can't be funny and engaging, you ought to ask him to one of your seminars, because he was wonderful.

I think it was this diverse group of individuals and the diverse program that made our summit interesting for people. Our next step is that our insurance and financial services cluster in Connecticut will take up the challenge of following up on some of the things that were talked about at this seminar, and they will take control of coordinating with the industry in the states.

I hope you enjoy your panel discussions today. And I hope it's as successful as our summit in Connecticut. Thank you.

TIM WAGNER: Thank you, Sue. Evan Mills is certainly well known to insurance regulators as a result of participating in the presentation on this topic a little more than nine months ago. But he has also — and this is a subject near and dear to my heart — contributed to the *Journal of Insurance Regulation* on this subject. I would like to thank him. He's written extensively on this topic — and has contributed what I believe to be one of the most important papers in the public domain with respect to insurance and climate change. Evan is sponsored by Ceres, which has been a leader in this process. I would also like to recognize Andrew Logan and Peyton Fleming from Ceres. They've all been excellent to work with, and they are clearly committed to this cause. I don't think I really need to provide a lot of background and bio about Evan, because he understands the issue and continues to advocate on behalf of it. So Evan, do you mind just taking it away? Thank you.

EVAN MILLS: I've been working for over 10 years on the intersection of insurance and climate issues. I am delighted to be here today to address this session.

At the risk of spending the whole time thanking people, I really do want to recognize Commissioners Wagner and Cosgwell for their vision and leadership in this area. It's remarkable that the NAIC has taken such interest in this issue. And I'm not sure if she was recognized already but, if not, Nancy Skinner was one of the first people to really bring this topic to the regulatory community.

So today, I'm going to build on a talk I recently gave in Connecticut, at the invitation of Commissioner Cogswell. Those of you who were there will see some of the same slides. I'm going to review the science, but segue a little bit more than we did before into insurance implications and, in particular, as the title suggests, into a little bit more of a customer's perspective than I and others have before. We talk a lot about the insurance companies, their vulnerabilities and the impacts — and that's an important conversation to have. But, in addition, we want to look at and think about the customer side. For those of you who were in the hearing earlier today on the national catastrophe plan, a central issue of debate is the customer's perspective, versus the perspective of the firms.

I want to recognize my two authors on the Ceres report, and I encourage you to pick up the update that was issued today. This report originally was to be delivered in New Orleans at the NAIC meeting that was cancelled due to Hurricane Katrina. My co-authors are Eugene Lecomte and Richard Roth. Gene is in his 80s now, and is retired from a 50-year career in the insurance business and has a long history in this industry, including founding the Institute for Business and Home Safety, which at the time was called The Insurance Institute

for Property Loss Reduction. Richard, as many of you know, was assistant insurance commissioner in California, an actuary, was very active at the NAIC and in several of its committees, and is an expert in catastrophe issues.

I will also be reporting today on work done jointly with Paul Epstein from the Harvard Medical School on the just-released Climate Change Futures study focusing on the health impacts of climate change, and I know the NAIC has been waiting for that report's release.

The work I'm talking about today was sponsored by several government agencies, including the U.S. Department of Energy, the Environmental Protection Agency and the U.S. Agency for International Development (USAID), as well non-governmental organizations like Ceres and the United Nations Development Programme (UNDP).

The earth would be frozen over, literally, without our greenhouse blanket over the atmosphere. And the good news is that in a normal climate, solar energy comes in and warms the earth and an equal amount goes up, so the earth doesn't warm up. The problem with climate change is when you make the greenhouse blanket thicker, more energy comes in to the Earth's ecosystem than goes out, which results in a net warming effect. And that's the bottom-line effect of greenhouse gas emissions, which is very well documented.

There are a lot of nuances. There are a lot of processes that take place in the atmosphere. There are natural influences and human influences, and some of them create positive warming, which is what the bar above the red line shows — and some of them cool the earth, which is what these bars below the line show. Humans do both, but the primary effect of humans are these two bars — fossil-fuel use and related impacts to the atmosphere — which create a warming effect. The ones that cool the earth are far overshadowed by the warming effect of fossil fuels. And there are uncertainties shown in these little bars around the method, but there are a lot of natural phenomena. Solar activity is talked about a lot; that's this last bar over here. Some people have asserted that that's the main cause of temperature shifts, but the scientific research has made it very clear that that's an important, but secondary or even tertiary, factor. Volcanoes put dust into the atmosphere that cools the earth. Humans don't only create GHGs (greenhouse gas emissions), but we also particulate in other things whose net effect is clearly in the direction of global warming. Activity in the agricultural sector, forestry sector — and even the contrails that you see from aircrafts — actually cool the earth minimally, because they reflect incoming solar energy. So it's important in climate science, in the modeling to include all of these plusses and minuses.

Impacts are both physical and human. Obviously, today we're more concerned about the ones on the human impact, but the physical sphere of water and air temperatures are affected, as well as the whole so-called cryosphere (the frozen world). That is, rainfall, soil and moisture content, which is relevant to agriculture; ocean current and sea levels; the permafrost in the north; and, of course, weather itself. So there are a lot of physical effects to think about and a lot of consequences for physical systems, health, agriculture, water quality and availability, and then ecosystems, some of which have very, very important economic importance.

So let's focus on the most important of those influences, which is fossil fuel. Here we see the rising CO_2 record. We have something like 30% more CO_2 in the atmosphere than prior to the Industrial Revolution. And the growth tracks exactly with the growth of fossil fuel use and the deforestation.

Impacts on the ground have followed. This chart shows a rise in numbers, not cost, but numbers of disaster losses. This is from an international database. It shows growth in numbers of losses, as well as the composition, types of events and the emergence of new things, like epidemics, becoming a larger share of the total.

The rest of the material I'll show you is essentially from the Intergovernmental Panel on Climate Change (IPCC) or it's been published since their last report in 2001. The IPCC is an international activity, involving 1,300 authors from about 150 countries and 1,100 technical expert reviewers. For example, the IPCC's 30-page chapter on insurance impacts received about 70 pages of review comments. It's a remarkable level of scrutiny. And so, the result — although it's sometimes disparaged by climate contrarians — of IPCC's work is very mainstream.

Since the IPCC's last report, the National Academy of Sciences (including 10 countries both in the developing world and in the industrialized world) issued a joint statement of conviction that climate change is here and that it's causing an impact. It's good to note that the United States was a party to both activities and accepted the IPCC's report on climate in formal plenary sessions. This photo was taken at about two in the morning in Geneva during one of those plenaries, showing us working through, comma by comma, the executive summary of the IPCC report.

The reason we have confidence in future projections is that the models have been validated. What we do is we point the models backward. The red is the actual temperature rise that we've seen. And the gray is what the models say the temperature would have been going back 100 years. And here, what you see in the first chart, is not a very good fit. The models don't match the temperature rise, because we've excluded the human effect on climate change.

The next chart shows what happens if you look only at human activity. And here it's a better fit, but still the red line and the past predictions don't match very well. It's only with the third chart that we see excellent validation of the climate change models; i.e., when you put both human activity and natural activity. This is why there's such a high level of confidence in the projection to be made of future climate impact. Keep in mind that these are global average temperatures that include minor changes over the oceans, but most of the warming has occurred over land, which is more material for us.

Here we see just some of the fingerprints of climate change. This is the melting of the polar ice caps that's already occurred between the late '70s and today: a remarkable 44% thinning of the polar ice caps, vertically as well as a shrinking of the footprint. This is a research vessel from Harvard at the exact North Pole looking at free water; i.e., a completely melted North Pole.

Greenland is also seeing actual changes in ice cover; up until a year or two ago, a very large degree of melting has occurred. This is a picture from an issue of *Science* magazine from just a month or so ago; it's one of the largest glaciers

coming off Greenland. This shows the leading edge of the glacier in 1992, and this is the foot of the glacier where they connect to the earth today. All of this disintegrated in the meantime; this is 10 miles of decomposed glacier in the period of a decade. If this is a 4-meter sea-level rise, you can see what it means for Florida: Miami is down here in the red. Greenland melting altogether is about twice this much sea-level rise.

The next chart shows the study by the Federal Emergency Management Agency (FEMA), showing sea-level rise in Delaware. These lines show expected encroachment of the seashore in just the next 60 years, and the loss of three rows of houses. This is the sea-level rise that has already occurred in the measured record globally.

One of the consequences of all of that ice melt is what is called the freshening of the salty water in the North Atlantic, which actually sounds like a good thing, but it's not. Normally, cold salty water from the north sinks and flows back toward the equator, where it warms and returns back to the north. That's called the "ocean conveyor belt." There are different names for it, but this is what creates the Gulf Stream. That's why Scandinavia doesn't have frozen ports in winter; they have free-water ports. Freshened water due to melting ice caps threatens to shut down this natural circulation pattern, changing weather patterns worldwide.

And one of the concerns, that until last week was considered something maybe to worry about in the next millennium, is a breakdown in the North Atlantic current. However, based on an article just out in a the peer-reviewed scientific journal *Nature* there's preliminary evidence, and there are uncertainties — that there has been a remarkable 30% reduction in water flow from north to south in the last decade or so. That's extremely worrisome, because what happens when this conveyor breaks down is that the agents cool, so there's much more cold weather in Europe and North America. Perhaps less relevant to this audience is that the monsoons in Africa and Asia break down, which creates obvious global crises in food and water availability.

This is how temperatures would change in the world if this ocean circulation broke down. It's a hypothetical, but it shows that there's a temperature increase of about 14 degrees Fahrenheit in the north and 5 degrees or so in the south.

This red is very important. Climate change can be abrupt. There is an assumption often made in the insurance risk communities that climate change will be gradual, so you can adjust premiums and your exposure in real time. But that assumes a nice, smooth rate of change. And a change like this can be very, very rapid. Abrupt change has happened in the past, in geological history — so it certainly has been shown to happen before — and then you'll get changes in the order of years and decades.

One thing I want to mention, in complete scientific fairness, is that there are benefits of climate changes, as well as costs. Those benefits and costs are distributed among different groups as losers and winners, but wouldn't it be nice if you could sail a ship from Europe to Japan without going through the Panama Canal? That's actually something that could be a reality. There could be benefits

for crops in certain areas. Some areas will have better tourism, perhaps; although other areas will suffer.

An important thing that is often overlooked in the discussion is that the balance of benefits and costs depends on the *degree* of climate change. Most studies and things you'll read about assume this scenario, the top one, which is two-times CO_2; i.e., a doubling of CO_2 from pre-industrial levels. But that's just a moment in time that we will, unfortunately, pass on the way to greater increases. With our continued growth, energy consumption and deforestation, we will shoot right through that point at around the middle of the century. We will pass three-times CO_2 by the start of the next century and four times not long there after. Then, we'll be in this scenario of warming and drying. This chart shows widespread drying in the heartland of the United States. Think about what this means for water availability and agriculture. So, the mix of positive and negative impacts will shift toward the negative as climate change progresses.

This is a complicated chart, but I just want to emphasize that we talk a lot in terms of averages, which are reflected in these kinds of bell curves representing current or future weather. Averages are important, but what's important to insurance is the right-hand tail, the extremes. The chart shows a relatively modest shift in the averages and increasing variability — which is why the curve flattens out — and we expect increasing variability. Under climate change, we've got a third of time spent in these extreme zones (as compared with just a few percent of the time before). That is an important subtlety often also lost in discussions about climate change: a lot of focus on averages. But as we know in other realms, no one is average.

Catastrophes are important. But more than half of the global insured losses from extreme weather are from non-catastrophic weather-related events, and here's a list of them. Blackouts, droughts, hail storms, other kinds of storms, soil subsidence are all very, very important. I encourage you not to lose sight of this in your deliberations about climate impacts on insurers.

Then, of course, location matters. We have multiple regions just in the United States, and multiple types of events. This chart shows winter storms, thunderstorms and tropical cyclone hurricanes. The green at the top shows hurricanes and cyclones. You can see the contribution to losses from hurricanes is less than the contribution from these other events. These smaller-scale events in aggregate are important.

The next chart shows the time period, again, for the United States. This is thunderstorms, and this is winter storm rising, inflation corrected, dollar losses. Many of these events are totally missed in the insurance statistic. Property Claim Services excludes from their database every event with $25 million or less of losses. There's not a single winter storm, for example, in this database from 1949 until 1974, because individually their losses didn't achieve the minimum threshold cost. But in total, we've got $3 billion a year in loss cost. It's like a significant hurricane worth of combined winter storm losses each year. Here, we've got $8 billion of cumulative thunderstorm losses in a single year. So this is catastrophic, even though it's not from an individual catastrophic event, but it's financially just as important.

This is another view of how important it is to consider impacts in the heartland. This is a map of presidential disaster declarations, and you can see, unless you all want to move to Nevada, that you're going to encounter these kinds of events everywhere you go. And, 99% of these events are weather-related. Earthquakes are important, but they're a small number of the total disaster events that occur.

I want to say something about the health-related consequences of climate change, and I refer you to the Harvard/Swiss Re report for more on this. Health impacts are important. Right now, the climate issue is located in the NAIC Property and Casualty Insurance (C) Committee, and that's fine as a start, but it's really only half the story and it's important that regulators also look at the health side. Heat stress, respiratory disease, food poisoning, infectious diseases, water issues, injuries from natural disasters and environmental contamination (that's a big issue in New Orleans right now) are among the specific elements of this discussion.

This chart shows the major health-related consequences for human systems, and then there are health consequences for crops and other natural systems. If it's damage to coral reefs, then there is less storm surge protection for your insureds' hotels. Detriment to forest health contributes to the destructiveness of wildfires and so on. So, impacts to natural systems can have links to very real socioeconomic impacts.

Respiratory disease is the largest single health concern for North America due to climate change because there are multiple coinciding insults to respiratory health. We expect 60% more pollen — which is an asthma and allergy precursor — under a doubling of CO_2. Increased CO_2 helps plants grow, and we're often told that that's a nice thing. But, if the plants grow, then there's more pollen. Also, mold growth will be fueled and nourished by more CO_2, as well as the moisture and humidity that comes from that. You don't need to look farther than the post-Katrina situation in New Orleans to see how important moisture and temperature are to the proliferation of mold. But also the smoke and particulates from wildfires from the burning of fossil fuel are obviously very important for respiratory health precursors to respiratory disease, as are urban air pollutants arising from fossil fuel use (made worse by warmer temperatures).

This chart puts the heat event in Europe in 2003 in perspective. You may not know, but the estimates went as high as 50,000 human deaths above normal in the summer of 2003 in Western Europe. This isn't Africa, this is Western Europe. And this is the event in context, shown by a nice bell curve of historical extreme weather effects all around Europe. And here comes this 2003 event out here all alone to the right. For those of you who do numbers, this is six standard deviations, six "sigmas" from the norm. Statistically, it's considered nearly impossible that this is a natural variation. It's one of the few real smoking guns that seem to be out there, perhaps stronger evidence than a smoking gun. It's a one-in-a-46,000-year event.

I now want to give you a few observations on wildfire. This shows the rising rate of acreage burned in the United States over time, despite increased suppression efforts. This chart is a simulation we did with the California Department of Forestry. We put climate models together with their wildfire

models. You can see that these are all changes from today's conditions. The worst area is the Sierra Nevada foothills, which is surely one of the fastest growing areas in terms of housing in the United States. We see the doubling on average of the so-called escape fires, the really catastrophic fires. In some subregions, we see a four-fold increase in the number of escape fires under the doubling of CO_2. This includes suppression, so the model includes all of the fire-fighting trucks and crews and airplanes trying to contain these fires.

Risk Management Solutions' (RMS) scenario for the United States of a future fire catastrophe is $4.7 billion of eventual losses. So, these traditionally small-scale events are moving into the realm of major catastrophes. There is a lot happening in this chart, but I just want to give a flavor of the complexity of the wildfire issue. We have a lot of different drivers (e.g., temperature and lightening) that create insect population explosions that kill vast expanses of trees. This is a picture from Alaska of vast areas of forest where we have 10 million or 15 million acres of dead spruce and other trees. Now, in the United States, that obviously creates a fertile ground for wildfires — together, the rising temperature and windiness that fans the flames.

After the fires (as we saw in California a couple of seasons ago), the rains come and create mudslides. The fallout is what we think of first, property losses, but there is also loss of timber value and, particularly, the health issues I mentioned before. To make matters worse, the smoke goes up to the atmosphere as CO_2 and amplifies the process of climate change.

The next chart shows an 800-mile expanse of Alaska from last summer. We had almost 90% of the inhabited areas with extreme health warnings or serious health warnings of one sort or another due to the hundreds of fires burning. The next chart shows photos of air quality conditions before and during the fires in Fairbanks; the bar chart shows health conditions on a daily basis. The green is good. The yellow represents moderate health risk. Everything else is varying degrees of severe health warning. This is Fairbanks during the fires and before the fires, a very serious public health issue.

Lightning is another small-scale event that creates large aggregate losses. State Farm reported $300 million of lightning-related losses in a given year, which represents 3% or 4% of their claims. This chart has lots of other numeric examples of lightning events. As the chart shows (this is from Hartford Steam Boiler), these are lightning claims vs. the temperature during the month of the storms. We see claims rising exponentially as it gets warmer, and this is widely recognized in the atmospheric science community.

The next chart shows the causes of wholesale power interruptions across the United States, 60% of which are due to weather events. Notice that lightning is an important contributor, but certainly not the only one. The RMS scenario for a power outage is almost a $3 billion loss outlook. The PCS data I mentioned previously excludes almost all power outages, because individually they don't result in claims of more than $25 million, although in aggregate they do.

This is a chart that's in the current issue of *Business Week* that we did showing global insurance losses due to extreme weather, corrected for inflation. Comparing that against population growth, insurance premiums and non-weather-related events, certainly we're moving more into harm's way. Certainly,

houses may be appreciated more than inflation in general, but when you correct for a lot of these things, we still don't explain this gap. There are reasons to think this is an underestimate from my prior remarks of a true loss. Think about all of the efforts we've made to suppress losses, including better building codes and so on … Despite all of the efforts so far, and we know they're imperfect — and there's a lot more we can do — our efforts are not stemming the tide.

Here is the effect on combined ratios for the U.S. property-casualty sector. The red line is the break-even threshold, so all of these here have a combined ratio of over 100. The green just shows the contribution of weather-related events to the overall combined ratio. This has business materiality for insurance, and it makes a noticeable difference in the overall underwriting results.

The next chart makes a very important point: About 10% of catastrophe losses are in the commercial and personal vehicle lines arising from big hailstorms and so on. But, also, losses to aviation, offshore energy, and then health as we've discussed is very important. Looking beyond the kind of core business to surplus lines, guaranteed funds, individual mechanisms, alternative risk transfer, risk retention groups, all of those, also have these exposures — as does the public sector flood insurance and crop insurance.

Let's not forget the emerging markets—that's where the future of the whole insurance industry lies — e.g., within the Chinas and Indias of the world — and the U.S. companies are participating heavily there. The impacts of climate change will be much greater in the developing world than in the industrialized world.

The next chart concerns the whole point about insurance availability. Here we have the well-known story of mold in Texas. This shows the number of claims going up for mold. This curve describes the number of writers in the state, showing a clear exodus of insurance writers from that market. Of course, mold is a weather-related issue. I'm not saying the Texas experience is directly attributable to climate change, but it shows the kind of response that can happen if weather-related events escalate, and this is a real issue for regulators, because of what happens to availability.

For underwriting, we're worried about the potential for climate change to compound existing problems. We have a mold problem. We have a construction defect litigation problem. We have a respiratory health problem. Climate change will exacerbate each of these.

Complicating the whole process of financing and recovering from disasters are shorter return periods and increased vulnerability. This is a nightmare for the actuaries. It makes the whole process of estimating these losses more complicated than it is now, and I think Robert Muir-Woods and others will talk more about that today.

For all off the phenomena I've discussed, we lack a good historical data series, and that's really worrisome. We can't use the past to predict the future anymore.

The next slide goes beyond underwriting, to other insurance concerns such as asset management. A lot of assets and financial markets are weather sensitive. You don't want a "double whammy" of losses in the underwriting side and erosion of asset value following widespread disasters. Real estate holdings are

sensitive to weather. In the wake of Hurricane Katrina, we have seen the operational side having difficulty operating in a post-disaster environment. So, increases in extreme weather events present a whole host of challenges to the insurance business.

On top of this, is the whole question of market power. Do insurers voluntarily leave a market or is it possible to manage the rising risks? Will overseas competitors have a relative advantage, because they're doing better scientific research and putting more effort into managing the climate risks? And then, more and more we're hearing about reputational risk, the shareholders, customers, are going to be increasingly expecting insurers to be ahead of the curve on this.

The next chart includes various recommendations for insurers. I won't go through it one by one in the interest of time, but there's a lot that can be done to improve data and improve analysis. There's more to be done in pooling risk in the industry, developing alternative risk transfer mechanisms, promoting loss prevention, building codes and land-use planning. Loss mitigation is very, very important, and this is just another reason to be doing it.

Then are the opportunities, such as lead by example. A lot of insurers are reducing their own greenhouse-gas emissions in-house and looking at new products that help address the root causes of climate change. I'm looking forward to Joe Boren's talk about how AIG is beginning to look at the opportunity side. This isn't just a gloom and doom story here. There are business opportunities for insurers in addressing climate change.

Next is the regulatory concern. This appeared on NAIC's Web site after Hurricane Katrina, which is a real recognition that availability is in question under climate change.

The next slide is a quote from Commissioner Tim Wagner reinforcing that this is not just a coastal issue. We really are worried about these events all over.

The next slide offers some suggestions for regulators on how to be constructive, looking at the standards of insurability. Insurability will be shifting and changing, and incorporating all of this into the day-to-day business of the NAIC will be a challenge. Climate change is not priced into the market, if you will, not provided for yet. I encourage insurers to do better with data collection and disclosure. CAT modeling can be a lot better, and Robert Muir-Woods and others are making great strides to improve the models. Right now, the climate modeling community and the CAT modeling community don't communicate much at all; therefore, the CAT models are based on assumptions that might not apply in a warming world. Climate models are based on the future. Combining these two families of models could yield some valuable insights and opportunities for managing climate risk.

Lastly, I think that as companies like AIG and others come forward, let's look for barriers and for things that regulators can do to enable the insurers to develop new products and new strategies.

Here's a quote from Marsh, again, recognizing the opportunities, not just bad news. We can be involved in the mitigation of losses, and we can look at new products and solutions as opportunities to manage risk and maintain its durability. Doing so would make the exodus that we're seeing from the Gulf less

likely. Risk can be spread more broadly over more policyholders, and that's desirable for everyone. There is a Web site where you can download this talk and other background materials: http://eetd.lbl.gov/ea/mills/insurance/index.html. Thank you.

TIM WAGNER: That was a chilling report. It lived up to expectations and then some. Thank you. We're now going to move on to Markus Aichinger, who is affiliated with Allianz as a scientist. Has does done a lot of work and published in the climate change areas.

MARKUS AICHINGER: Thank you. My name is Markus Aichinger, and I'm a meteorologist who works for an insurance company. In talking about climate change, I want to first talk about what climate is, what drives the climate, why it is important for us as an insurance company and also why it is important for insurance customers. Also, what are the trends, what do they look like and what can we do about them?

So this [slide2 – red dots] is showing the temperature stations around the globe, illustrating what climate basically is: It's just regionally and timely averaged weather conditions. So, when you talk about climate, you should not mix it up with weather. And if you take the average across, for example, the Northern Hemisphere, with all the dots, then you end up with this kind of plot [temperature curve; slide 3], which is just another representation of what the slides before showed [referring to previous presentation]. But what you can see at this point is that the most rapid increase actually happened in the last century.

If you look at the regional impacts, then you see that it is quite different [slide 4]. The Mediterranean temperature was quite resistant to change over the last 100 years and in just 30 years (since 1970), the most rapid increase in temperature, of more than 2 degrees Centigrade, occurred. In the, what I call, tropical cyclone source region, we see a slightly different picture. Again, here in the last 25 years or so, we saw a rapid increase in temperature. But now, basically, we are going back to conditions where we were already in the 1900s. Please remember this picture, we will refer to it later.

So, climate change is, in fact, a fact. And the only constant thing in climate is that it is constantly changing. You saw pictures of the global ocean conveyor belt already [referring to Mills presentation] and you know that it is changing. So this is a long circuit that actually acts as an air-conditioning system, bringing the warm air to the north and giving us quite a nice climate. It also brings the energy from the Gulf region toward the north and similar things happen also in the atmosphere; for example, winter storms. They also tend to bring the cold air down from the north and the warm air up to the Polar Regions, and basically try to cancel out these horizontal temperature gradients.

Hurricanes have been doing nothing else. Once they recurve … and here is one, actually [slide 7]. So, once they recurve out of the tropics, they also transport the energy up to the north.

So what drives the engine? It's nothing else but the sun. And you learned about the global atmosphere and how the greenhouse effect basically works [referring to Mills presentation], but if you just look at the energy that is radiated

down, it's about 100,000 times what the United States in total per year actually consumes. This is the same as about 1,000 average-size hurricanes release in thermal, not kinetic, energy. As we know, this energy is not distributed uniformly around the planet. The tropics get more, the poles get less, and so the oceans and atmosphere transform this energy in what we know as weather systems and act as an air-conditioning system.

Here [slide 9], we have the three most famous weather systems we are talking about. On the right-hand side are the extra-tropical cyclones, which are the largest storm systems on our planet, covering about 1,000 kilometers with damaging winds. Hurricanes are somewhat smaller in size, but more intense. The most intense storms are tornadoes. Wind speeds of up to 500 kilometers an hour are theoretically possible. But, luckily, they are confined to small areas, a couple of hundred meters wide and a couple miles' long path of destruction. But the worst disasters are in fact hurricanes, as they combine incredibly high intensity with a decent size.

So to cut it short: "Climate is what we expect! And weather is what we actually get!" Weather is also what causes the losses. This is why it is important for us as insurers. If you look at the economic losses, here [slide 11] you see a quite even distribution across hurricanes (or actually windstorms), earthquakes and flooding. They are all causing about the same amount of economic losses. Among the "others," we have hailstorms, landslides, avalanches. What you can see is that more than two-thirds of the economic losses are related to atmospheric perils. According to a Swiss Re study from last year, in 2004, these were $120 billion U.S. dollars. And, a United Nations Environment Programme Finance Initiative (UNEP FI) program study stated that this number, in about 10 years, could rise to $150 billion per year. So, 2004, which was by now the most expensive year, might become an average year.

The picture looks even more striking if you look at insurance losses. Here [slide 12] you see that three quarters are coming out of storm disasters, and about half of it is actually attributed to hurricanes — as I mentioned earlier, the most destructive storms. Only about 10% of losses are from flooding and earthquakes. This is mainly because insurance penetration for flood and earthquake coverage is not well established worldwide.

So, 85% of insured P&C losses are coming out of the atmosphere. This was $46 billion in 2004, and we see significant trends. If you talk about trends and global warming, what would be the most obvious trend? Of course, we heard about that today: heat waves! Well, I have stated here that 2003 was the hottest summer in 500 years. So, it depends on the distribution you fit. This is the uncertainty if you talk about extreme events [referring to Mills presentation; he stated 2003 as a greater than 10,000-year event]. It caused 27,000 excess deaths across Europe, half of those in France. It could be even more. And it's now modeled to be four times more likely as a result of global warming. In fact, heat waves and cold spells can cause higher death tolls than any other weather-related disasters. And, most often, it's the elderly people who are most affected.

If you ask a meteorologist what would be the most prominent trends due to climate change, he would probably say it's the speeding up of the hydrological cycle. In the trends in floods, we will see the most prominent changes. What

does this mean? The global climate models predict about a 1% or 2% increase in the global precipitation. What does this number mean? The 1% might sound like nothing. But there's also a physical equation called the Clausius-Clapeyron equation, which tells how much water you can have in a certain amount of air. This increases seven times as fast per degree Centigrade. What you end up with is a situation where you have dramatic flooding in one year, like in Dresden in 2002. Here is the same location in Dresden in 2003, a record summer, where you could literally walk through the Elbe River, which is usually several meters deep. [slide 14].

So, there was a complete absence of rain for almost an entire summer. This is not contradictory, but global warming causes both extremes, due to this speeding up of the hydrological cycle. Once the glaciers in the Alps are actually gone, then my house near Munich might have a problem getting drinking water. Projections now are that this might only take about 50-70 years. This is within a human being's lifetime.

Talking about hurricanes, here [slide 15] we see again, a very rapid increase in the non-inflation adjusted losses. These are raw losses per decade. But, if I plot the number of tropical cyclones making landfall along the U.S. coast, the picture looks a little bit different. Again, we see an increase here since the '70s, but we are still not there — even with the active season in 2004-2005 — where we already were in the '40s. So what actually causes this ever-increasing and rapidly increasing trend in losses? Well, if I plot the coastal population development — for example, this is the Floridian coastal population development — I think the trend looks similar along the entire U.S. coasts. There is a quite high correlation to this increasing trend [in losses].

There are studies that take population and wealth growth, inflation, insurance penetration and almost everything into account to normalize these losses, like the Pielke/Landsea study. Then you end up with the red bars, which show that we are basically where we were in the 1920s, and in the meantime, we had a quiet, nice, calm period. But now we're turning back to what I would call normal conditions. So, quite high activity.

The height of the bars is a little bit difficult, because here I assumed a 1926 hurricane of $50 billion. There is a new study out from the National Hurricane Center that said it could be $100 billion. But, also, I took for Katrina, which drives this bar here [period 1996-2005] only to about $35 billion, according to a PCS study. It could also be $60 billion. But the key message is basically the same: If you scale up both bars you end up with the same shape.

This [slide 16] is a plot showing the total number of hurricanes in the entire Atlantic basin, not just focused on land-falling. What you see is that there is an increasing trend, especially since the 1970s; we have a record increasing trend here. But we have to take into account that prior to the Second World War, there was no systematic observation, no hurricane hunter planes flying out in the ocean there and examining the hurricanes. Satellites have been used since the 1970s and dropwind-sondes were used just since the 1990s to identify the intensity of hurricanes.

If you try to scale the pre-World War II seasons, then you end up with this kind of picture [slide 17]. What you then can clearly identify is that there is

somehow a natural cycle in activity, and that we are now in a period of a rapid increase in activity. No matter whether it is man-made or natural, we have to face that we are now seeing increased hurricane activity.

This is the temperature plot [taken from slide 4], and we see that there is a really good correlation between temperature and the number of hurricanes. So, we can suspect that, if warming continues, we also will see on top of this natural cycle that there might be an increase in hurricane activity due to a man-made trend.

Having mentioned the trend of coastal population, this is a very nice picture taken from space at night [slide 18]. You can see Florida, Europe. This actually is a tsunami-prone area here [pointing to the Mediterranean]. People just love to live at the coastlines because of the nice view. They usually get together in big cities. This is Paris. Lothar was a storm that directly hit Paris and caused a $6 billion dollar loss; impressive for a European windstorm. And, of course, we all build our most expensive houses directly at the coastline, especially hotels. We all have nice little pleasure crafts there. I don't. But it seems that there are some people having some fun. And you all drive nice little cheap cars, so even hail losses might be a big issue in the future.

If you now take the 1926 Miami hurricane, a new study said that this storm could cause about $100 billion U.S. losses if it hit today. If you look at the track, then you see that there was a sharp turn to the north, and here's New Orleans [slide 19]. So this storm, it was still a Category 3 when making second landfall, could have caused the same disaster as Hurricane Katrina. Plus, it did hit Miami. So you could add another $50 billion to this number. This is the kind of loss amount you could face.

To summarize everything: Trends are statistically hard to identify, because we just don't have a time series dating back far enough. But we know that there is physics involved, so that is the climate models. And we know how the atmosphere should react. Temperature will continue to rise, so we have to expect more extreme events. We have to actually account for an increase in hurricane activity, whether it's man-made or not. And of course, the average loss cost for any disaster will increase due to the social trends.

So the question really is justified: Will insurance be around for these kinds of risks?

Well, the preconditions [for insurability] are, of course, that it should be a random process, it should be quantifiable. We have to follow ethical rules. And, the most important is that the insurance industry has to have enough capital to pay the losses. In my opinion, this is actually an effort that requires joint forces of science, insurance and clients — especially also the government, because the government has to set up the framework.

As insurers, I would say we need to get a more precise prediction about which local impacts we can actually face. It's hard for an insurance company to know what 1 degree of global temperature increase means. But we need to know what it means for European windstorms, for hurricanes or for flood events.

Insurers should do what their core business is: They should do risk management and they should actually optimally use the capital that is available. In past times, insurance companies failed to do so, because they attempted to get

as much business as possible and make money on the capital markets. I think these times are over. So, we have to go back to real risk-based pricing.

An insurance company has to be profitable! If an insurance company loses money in the core business, it won't stay around for a long time. And then, insurability is not a given anymore, because there is no insurance company.

What I mean with clients, for example, is that for insurance companies to do risk management, they need information about the risks. So, we need details to know where the risks are and what the risks are. Even so, if clients want to live at the coastline or at the river, then they have to accept a certain sharing of the risk inherent. Because, still, insurance is a system where you actually share risk among a lot of individuals. As you know, you can't just cross-subsidize anybody who wants to live at the coastlines. And, very important: Mitigation measures should also be supported.

In the past — and I am just seven years in the insurance industry — the insurance industry was always quite innovative in finding ways to insure whatever risks there are. Now, there are even special terrorism insurance companies out there in the world.

So what should the insurance industry do? I think CAT modeling is one very important thing —even if it does not yet factor in climate change, but at least it gives you an idea about your exposure and potential cost due to natural catastrophes. Besides CAT modeling, geographic underwriting is key, because there are also some risks for which there is no model available yet. So, still, you have to define how much exposure you want to take in a given region.

Regarding in-house research or supporting external research, I would say in-house research is important. Some of the big reinsurance companies set up their own research teams. But you can't request any insurance company to build up a team of natural science experts. The bigger ones, at least, can actually do so.

Consultancy to clients: Risk management is the core business of insurance companies. So, we should all go out there and advise our clients on how they can mitigate their risks.

Product development: Of course, deductibles and sub-limits are one part of further development. What I mean here is to actually find new ways to insure certain risks. And to join forces between, for example, asset management and insurance or construction companies and insurance, and to insure, for example, renewable energy companies.

So, I would say the main take-away for me is that insurance companies have to go back to more discipline. We should not sit back and watch it coming. We all know that climate change will bring more risk, and risk management is what we can do best as an insurance company. There are opportunities out there, and you should take advantage of these opportunities. Thank you.

TIM WAGNER: Thank you, Markus. That was an interesting presentation. Our next speaker probably needs very little introduction: Robert Muir-Woods, foremost CAT modeler and research director at Risk Management Solutions (RMS).

I go back to a personal experience that I had in modeling, back in 1974 — if you can believe that — I was given the assignment to predict where hurricanes were going to hit in Florida. And I had this map. And I had every hurricane from time immemorial on that map. I can still remember where the dots were, in fact, I studied it so intently. And, we hired the retired director of the National Hurricane Center to create a program, a modeling program, if you will. Unfortunately, he passed away before he was ever able to execute, because at that time there were only two computer systems available in the United States to handle that program. One was at Boeing and the second was NASA, so he never really got to execute his program. Today, we have that much computer power on our desks.

Now, we'll hear from Robert. Thank you.

ROBERT MUIR-WOODS: Thank you. In honor of that glorious scientist of the past, I'm going to tell you about what CAT modeling does today. You've heard a little bit about the scientific background, and I'm going to run through what happens next, when one takes science and applies them.

For those of you who don't know what capacity modeling is, it's essentially the interface between science and its application to insurance and reinsurance, with pricing and portfolio management. RMS employs about 350 people — including about 60 scientists, engineers and mathematicians — who work on all aspects of looking at catastrophes. Using climatologists and meteorologists, our experts look at the effects of extreme weather using a modeling process that goes about creating 100,000 different versions of weather events, when you simulate the whole range of possible events.

We're completely independent of the insurance industry, and we survive on being objective. I'm here today not because I'm promoting a particular point of view about climate change, but because we've gotten to the point where climate change needs to be included when thinking about actually modeling for the near future. So, it is relevant; it is potentially relevant to a number of perils. However, the front issue, and what I'm going to talk about today is hurricane risk, because that's where, if you like, the rubber has hit the road.

This is the output of our catastrophe models; it's a hurricane model for the United States. This shows you where the risk is concentrated. You see that the hot spot of risk in the Mississippi Delta, which was hit by Hurricane Katrina. There's a hot spot of risk at the southern end of Florida and hot spots of risk if you go up the East Coast, in addition to the various capes sticking out into the ocean. This is simply because that is where the track of storms tends to intersect the land. This is, if you like, imbedded in the model. There will be core information about what is the fundamental, or what we call the technical, price for the risk; that is, the amount you would set aside each year to pay for all of your future losses.

Why are we talking about hurricanes and climate change? Well, the past two years have been pretty exceptional. Just to give you some statistics on this, on average. What happened in 2004 … what happened in 2005 … You can read these numbers, this year, the last hurricane of the season, Epsilon, was named a hurricane yesterday. This year has actually broken a number of records: for the

number of main storms, the number of hurricanes, the number of Category 5 storms (three this year). The number of U.S. Category 3 to 5 landfall hurricanes were all record-breaking. That was in excess of anything that has happened over the past 150 years.

On the right-hand side, I've put what the factor was of this year over the average. What you can see is that the statistics that relate to the frequency issue across all classes of storms, specifically about 250% of average this year, from the number of names, the number of hurricanes. But if you go to the severity measures, Category 5 storms this year were 7.5 times the long-term average, or the average for which we have good data since 1950. The number of landfall in Category 3 to 5, were six-and-a-half times the long-term average. In fact, we insured losses this year at about eight times the long-term average. This was by any measure, and by a whole set of measures a pretty extraordinary year. And it followed another year, last year, which was also fairly extraordinary, too. It didn't break quite so many new records, but it was also exceptional.

So, what is going on? In order to give you a little bit more background before going into that, I'm going to give you a very quick "*Reader's Digest*" version of what is the basis of knowledge of the science when it comes to thinking about climate change and hurricanes. Before this year, some of the key most scientifically credible data related to hurricanes and climate change were, in particular, a paper by Tom Knutson and Robert Tuleya. Tom is a physicist and climate modeler based at Princeton who works for NOAA. This paper looks at a whole series of climate models under conditions of double CO2, about 2 degrees warming beyond the original 1950s, 1970 baseline. What they found across all of these models was about a 6% increase in the wind speeds of hurricanes, which is about half an intensity measure on the Holland scale. This work is well regarded; it's not particularly controversial. Now, a double CO_2 condition is something we might expect in about 50 years' time. This is what people are going to ask themselves: OK, how much increase did we expect at this time? The answer was not much, because if that's what we get after 50 years in the future, by now we might only have got 10% or 15% of this increase in severity — and that might not even be observable.

If we look back at what has actually happened to tropical Atlantic sea surface temperatures, you see a warm period in the 1950s, it then got cooler in the 1970s and 1980s, and then there's been quite significant warming that has taken place since the early 1990s. And, that warming in relation to the cool period of the 1970s and 1980s is attributed to about half a degree centigrade of warming across the equatorial Atlantic, which is most critical for the region in which hurricanes are formed.

This year, two papers have been published that have both been very provocative and have effectively shifted the agenda a little bit about hurricanes and climate change. The first was published by Dr. Kerry Emanuel, in the journal *Nature* in August 2005. Dr. Emanuel is the leading semi-dynamic test in thinking through the structure and the behavior of hurricanes. And, he had been a climate change skeptic until about eight or nine months ago, when he suddenly switched sides, much to the surprise of his colleagues, and became a climate change champion. It was based on the fact if he had looked to see the cumulative

potential destruction in this index, which simply summed the maximum wind speeds times the number of six hour intervals throughout the lifetime of the hurricane. He found it showed a very strong correlation over the sea surface temperature in the equatorial blanket region.

Now these increases in the destructiveness index, and I'll come back to that, they were much greater than what was expected for the level of sea surface temperature increase that actually Knutson had predicted in his various papers leading up to 2004. In fact, there's a lot of controversy in the climatological community about whether Kerry Emanuel has provided some corrections to the hurricane intensity basin before 1970, and there's kind of controversy about whether he should have done that. But, in fact, people are reasonably happy with his data since the 1970s. It does show a profound relationship between the destructiveness of hurricanes with some of the, effectively, energy release, and the sea surface temperatures.

The second paper, in the journal *Science* in September of this year, was published by a climatologist who specializes in looking at monsoons typically, but looked at the population of tropical cyclones all around the world. He found that, in fact, there had been no change in the total number of tropical cyclones found in all regions of the world. However, if you look at the intensities of these hurricanes, of these tropical cyclones (hurricane is simply the local Atlantic name for tropical cyclone), what you appear to find is that the proportion of these storms in different intensity paths have shifted over time. So, a greater proportion of these films marked in red here are in the higher intensity categories, the Categories 4 to 5, than had been previously. This is simply showing the distribution of both tropical cyclones by intensity class over time. It appears to show that while the total number hadn't changed overall, it had changed very likely, but overall in the world hasn't changed. But the portion of those films that have been higher intensity classes has been writing. This is fairly similar to what Kerry Emanuel responded to the Atlantic, and to the rest of the Gulf region.

These have both given a big shift, a big kick, to the climatological community in their understanding of the interrelation between climate change and hurricane.

Now, the activity of hurricanes, some very odd things have been going on in the past years. I showed you those records about this year in relation to the past, but this year, a number of records were broken. In fact, this is the first time ever that we had two Category 4 storms form in July; that never happened before. In fact, what's shown here is really complicated to see; it's simply the intensity of these various films that formed in July this year, superimposed on a 2-degree grid, of what had been the previous minimum pressure in that 2-degree area. In fact, the colors get brighter because of high intensity. The storms are significantly more intense than any hurricane that ever passed through this region in July in previous years. This is a pretty extraordinary feature.

Another thing that has happened over the past couple of years is that the hurricanes have started forming in places where they haven't formed before. So, it seems that not only have they increased in number, they've actually started going to places where they didn't go before. This hurricane that went through

into Halifax, Nova Scotia, in September 2003 is a Category 2. This is Cyclone Catarina, which is the first-ever tropical cyclone identified in the south Atlantic, which was seen off Brazil in March 2004. This was the Hurricane Alex, which was the first Category 3 from north of 38, north in the Atlantic. This is Hurricane Ivan: This was both the most southerly and longest-lasting intense hurricane in September 2004.

So, records have started to be broken in a number of things. Hurricane Alex, being the first Category 3 storm to form north of 38, north in the Atlantic. Hurricane Ivan was both the most southerly and longest-lasting intense hurricane in September 2004. So records are starting to be broken in a number of things, not simply by the number of them, but where they go, the geography of them. In the last few weeks, there have been two hurricanes, one heading toward Portugal and the second one, Epsilon. One before Epsilon was heading for the coast of Morocco. It wasn't actually going to be a hurricane at landfall, but the fact that they're starting to point at places that were previously completely outside the hurricane belt is somewhat curious.

Going back to the main thing I want to talk about, is what this means when we think through the hurricane activity in the United States. We've done a lot of work. We've had somebody doing nothing but actually working on hurricane activity-related issues about the past six months — every possible way of investigating, sampling. We think one of the best ways of thinking about this is to look at the most intense storms. The most intense storms share a much stronger signal in the whole population of hurricanes. And, in fact, the most intense ones are the ones called the Category 3 to 5 storms, what they call severe hurricanes.

Severe hurricanes, currently, the number of Category 3 to 5 storms is today, this is a number per year, and a red line shows a five-year running average. The number over the past 11 years has seen about twice the number than what existed in the period between the late 1960s through the early 1990s.

There's another period of high phase of activity of intense storms and 1950s. So you see there was a high period, then it dropped down again. It's actually gone up. And, in fact, it's actually gone up in the last couple of years, even higher than any five-year average of the 1950 period.

It's not just a matter of how many of these storms there are in the basin, it's actually what proportion of them make landfall, which is critical. There are two key factors: the number of storms and the proportion that made landfall. The proportion is just as important, and sometimes even more important, than the number, because that has actually leveled around for a time. This shows the proportion of Category 3 to 5 hurricanes that have made landfall in the United States. You'll see they actually drop down to the lowest level seen, certainly since 1950 in the period of the late 1990s, so a smaller proportion of these storms are making landfall. This is the period when we had the storms like Floyd and Lili and Isabel, which looked too spectacular off shore, they were Category 4 offshore, and then they fizzled out before they made landfall.

We started thinking this is the way things were. In fact, there are even some theories around that maybe climate changed had not only increased the number of hurricanes, but actually had formed some kind of protection via a "trough"

formed along the East Coast that kept the hurricanes offshore, and that was popularly discussed at that time. However, it didn't last, because what has happened in the past two years is that the hurricanes have shown an increase in the probability of actually making landfall. So, it's swung back again. Over time, we expect this will regret back to the median, which is about 27% or 28% of all of the Category 3 to 5 storms in the basin to actually make landfall at that intensity.

So, where is the debate currently? Just to highlight what the debate is around climate change … Emanuel identified intensity increases, which he has admitted are about four times greater than come from the model predictions of the work by Knutson in regard to the sea surface temperature increases. Then there's an intense debate going on at present in the hurricane climatological community as to the role of climate change. While there are strong denunciations of the work by Emanuel, there is also support for him. I've been at meetings where he has spoken, and he's swung the audience of climatologists around to support him. There is consensus that some part of the increase in the Atlantic equatorial oceanic temperatures comes from global warming, and there's an acknowledgement, also, among all climatologists that the activity in 2004 and 2005 has been unprecedented. The second position — if you like, the Emanuel position — says, yes, we've seen a cycle, but, in fact, this trend has been superimposed on top of that, and the trend has started to become bigger than the cycle itself.

What does this all mean when it comes to thinking about modeling going forward? One of the challenges is, as I mentioned, a smaller proportion of the most intense hurricanes was making landfall. This is looking at how that proportion has changed over time. There is about one Category 3 to 5 hurricane making landfall in the 1950s. That dropped down to about 0.3 storms a year in the early part of the century. The average over the past 11 years is slightly greater than 0.9.

So, what is that average going to be moving forward? Well, we decided a couple of months ago that this problem was bigger than a CAT model. So we actually convened a session involving three key climatologists that represent different perspectives on planet change, with considerable depths of knowledge, of all facets of hurricane activity, hurricane climatology. We actually got them to arrive at a consensus on what was going to be the activity of hurricanes at landfall as well as in the basins over the next five years. And this is just some headlines. They're writing up a paper based on this that will give much more details.

First of all, the increase in activity rates, we see, is basically a function of oceanic temperatures. The Atlantic activity in the next five years is expected to be close to the average we've seen in the 1995-2005 period. We can assume there will be one El Nino in the next five years. The land-falling rates are expected to be about somewhere between 25% and 35% higher than the long-term average. There will be a bigger increase in the landfall in Category 3 to 5 storms. Global warming is expected to prevent the next period of low activity, from low activity from being as low as the 1970s and 1980s. It will probably never go back down in the next two decades to the level of activities that people

lived through and built their properties to, and designed their oil refineries on the beach, too, in the 1960s, 1970s and 1980s. So, this is sort of the broad headlines of their conclusions. We have the job of seeing how that will be implemented, because we actually want to take that and build it into our CAT model.

This is what we're doing. We're actually stating specifically that the intention of the model going forward is to represent the next five years; it's not going to represent next year. It's not going to represent the next six years. It's going to represent the expected activity of the next five years; the next five-year horizon being 2006 to 2010. We will update the rates in the models when the science reports the different activity rates, the better the long-term means. The rates may be updated annually where change is implied. The hike in the 2006-2010 rate is likely to reflect some contributions in climate change. Now this is, if you like, what we can say on it. This contribution is somewhere between about 10% and 60%. Now, I'm not telling you what I think it is, but it's somewhere in the middle of that range. I think we believe this just sort of captures the climatological consensus on the issue. So, we're increasing activity rates in our model. Some component of that is going to be a function of planet change.

What is this going to mean? Well, one thing we can do to sort of show you is do some stress tests around what impact this is going to have on modeled risk for the insurance industry. Now what I'm going to show you now is stress test only. I keep saying it's a stress test; it is not the results you're going to see when the commune (ph) model is released in May of next year. This is showing you what different stress tests do in terms of losses and key returns period, which insurers and reinsurers will see, well actually would see, I should say if we'd done them.

So, actually, the lower one in yellow is showing what happens if you apply a 33% increase in the activity rate of all storms in the model; it actually increases your 100-year loss by about 12%. It increases your average annualized loss by 33%. If you apply a 6% on all wind speeds, and leave the activity rate unchanged, you effectively up the intensity of the storms by 60%, you effectively get about a 50% increase in the level of loss of all return periods, and a 50% increase in average annualized losses in the technical rate, the hurricane. The top one is if you mix these two together, and you'll see an increase in average analyzed losses, so an increase in a technical rate, and that your 100-year return period, you'd be up about 70%.

Now, what we're going to do is none of these. These are sort of stress tests that show you some of the things that are out there. These changes will be coming through in our hurricane model, along with some other things that are being learned from the 2004 storms, ending with Katrina. Some components of these changes are going to be related to planet change.

What is this going to mean? I'm going to show you, and take you sort of through a quick tour about what I think this is going to do to people thinking about risk and actually using the models in managing risk. In fact, it's a shame how much the risk costs would go up for Miami. This is actually showing output models for our variable resolution grid, showing the risk cost we are outputting from Miami. You see the risks costs have actually gone up by a third, and this is highlighting the degree to which everywhere in Florida is actually going to be

subject to the increase in the technical rate of hurricanes as a result of what we do. But the risk costs already are very high.

When it comes to looking at storm surge flooding — because an increase in the severity in the activity of hurricanes also pushes up the height of the storm surge the intensity of the storm surge — it's also going to increase the significance of storm surge as a source of losses in the costal areas. In fact, we're going to represent an increase in the frequency and in the severity of the storm's impact. You've got a huge amount of destruction. This is going to happen more frequently in certain parts of the coast, and then that is going to be a bigger contributor to losses. So, this is just showing you, again, for Miami, actually how we represent a bit of stress tests in the increased activity rate in terms of the impact.

Now, I want to run through quickly three broad classes of impact that are going to come. We actually try and make a representation of what is about to happen. This is a central representation of risk costs coming from the coast; it is rising as we get toward the coast here. The flood rates, and I'm showing you the 100 year return period, flood rates rises dramatically when you apply to the risk cost, because storm searches can have such huge impacts.

If you put the two together, that is what the total risk cost of hurricane looks like if you approach the cost currently. This is actually in the approval process, the hurricane rates, which is typically done in ZIP codes. The average across the ZIP code itself, which means the people living on the coast tend to underpay their actual risk to keep people inland on that ZIP code may overflow slightly. If we look at the National Flood Insurance Program's flood rates — which are not well designed to actually capture the true cost of risk and tend to cross-subsidize people who live in the highest risk classes close to the coast —they might be like this. So you see there's a deficit. The people who live at the coast, they are effectively being subsidized for choosing to live there in relation to people who live inland.

This is going to become exacerbated when we go to the new perspective, the same thing. We're going to come up with new wind drift, which is going to be higher than it is at present. You're going to come up with a new flood risk, and that is going to further inland than it does at present, as well as be much higher closer to the coast. And then we put these two together. As you can see, we have a dramatic increase in the risk.

I put the Bahamas on here, because the Bahamas is interesting in that they have a perfectly free market with regard to insurance. There's no regulation. The insurance covers both wind and flood in the same policy because they actually use the UK insurance system. And we can see a little bit about what life looks like in a totally free market world with regard to an increase in risk. This is what has happened. On the island of Abaco, it's being hit by two storm surges, two big hurricanes in the past 10 years: Floyd in 1999 and Frances in 2000. All of this is probably being studied twice, someone conveniently made the remark as to how high the storm surge reached in Floyd. This house is still insurable, but the rates have doubled. This area which is the in the northern shore of Grand Bahamas, you can no longer buy insurance because they've been flooded by storm surge three times in the past 10 years, and insurers refuse to cover it,

which means that people are simply abandoning their houses and moving out. However, there's a free market response to this, which is some people have started building houses on stilts. This has actually brought them back into insurability again, because they actually can be protected against storm surge.

This is what happens. It's a total free market response that that is a recognized increase in risk. And I'll tell you, the United States is not a free market when it comes to insurance. If you like the functions of this meeting, if you look at how regulation actually relates to that. So, what is going to happen in the United States? Here's the new wind risk. Here's the new flood risk as we increase the risk associated with higher numbers of hurricanes. This is the National Flood Insurance Program flood rates. There's a huge—there's a big unfunded risk costs, an unfunded risk cost that's larger and larger. That is the situation at present. Because you have not got a free market for implementing or for adjusting rates to actually what that risk is. I already expect to catch up with the reasons for why the risk itself has been moderate has actually gone up. I would imagine the National Flood Insurance Program will take even longer to actually adjust its rates around it.

In terms of actually seeing what's going to happen, we can see some examples of things going on. In Massachusetts, their plan was set up to provide coverage for people in urban areas. The hurricane risk, in particular, also various classes of insurance, has found itself transformed into a coastal windfall by accident. Mainly because the modeled risk in Massachusetts changed, because the models became higher resolution, and put up the risk prices in coastal areas, and it's mainly the FAIR plan has found itself to come and transform it.

If we look to see some other examples of what has happened where there's been a mismatch between the understanding of risk and the regulatory response to it, one will be in California in 1995. There was an insurance crisis, because the insurers had just lost $53 billion in the Northridge Earthquake. Fifty percent of that was 28 times the 1993 earthquake premium. There was a big capitalization crisis, and they tried to demand increased rates and threatened to exit the state. As a result, the California Department of Insurance set up the CEA, the California Earthquake Authority, and that then applied a new contract type with a raised deductible that provided less coverage than before.

One of the consequences of that is that the amount of insurance being purchased in California dropped from 30% in 1994 to around 14% today, which is lower than in the country of Turkey for earthquake insurance. The next major earthquake in California is going to be a crisis as people discover how little recovery costs is provided by that insurance industry, a bit like Hurricane Katrina, especially in some of the poorer parts of New Orleans. Except that Californians, I expect, are going to be much more vocal and effective in protesting about what has happened.

I'm sure, in the aftermath of the event, there will be pressure to reduce the high deductible and expand coverages, as is currently going on in the states affected by Hurricane Katrina. Meanwhile, with the voluntary commercial market, price controls are thriving. This provides a lot of coverage which makes for a very successful market. This is what has happened in California.

One of the issues around the coastal flood risk is if the flood zones move inland because the activity has increased, there is a population of people who didn't even know they were in a flood risk zone, and suddenly wake up to find their houses flooded. If we look at and see what happened in Katrina, along the south coast of Mississippi, we can actually map the losses along the coast. And this is actually, we've actually done this in great detail, actually mapping the level of damage using satellite imagery all along the coast.

What I'm showing here, we're plotting the damage of some minor to moderate to total, the total is actually the red color. Here, the national flood insurance zones, so the "Z" zone, the zone where you expect total destructions in storm surges due to wave actions. The 100-year return period flood zone. And the 500-year return period flood zone. Now, you'll see there's a whole zone where the people's houses were destroyed by the flooding of Katrina, and they didn't even know they were in a flood risk zone, because flood risk zone did not expand that far inland. These flood risk zones were drawn up at a time when there was lower hurricane activity, and people had not predicted there will be events like Katrina affecting this coast. So, we have this strange anomaly, actually set up around who covers the flood risk in these situations and that they wake up to discover your house is destroyed and you didn't know you were in a flood risk zone.

So, what is going to happen? Well I suspect, I would predict, there's going to be a crisis, a Gulf Coast and Florida insurance crisis. I think the question is, can it be avoided? I think—I mean, I know— the model hurricane rates will rise significantly in 2006, principally in the Gulf and Florida. There will be an immediate expansion of underwriting by the FAIR plan alternatives, where people maybe are being dropped. There's this ongoing litigation around flood payments by the homeowners, and it is not quite clear where that will lead. The future of the National Flood insurance program is still in question at present, because the flood risk maps from which its based it needs to be redrawn. It underestimates the risk in a number of areas, and there are a number of question marks about the degree to which cross-subsidies exist in the National Flood Insurance Program.

So, what should we do about this? If you like, the best solutions in this kind of situation emerge where all of the stakeholders are equally informed with the technical understanding of the risk. This is fundamental in CAT modeling; we believe that actually this information should be out there at a high regulation as possible. It still needs to be credible, scientifically well founded. But actually once it's there, once people acknowledge it, then they can decide how it should be used, or actually explore how to manage the risk.

We, the regulators, need to stay abreast of changes, and how risk is defined, including the degree to which climate change is a contributor to what is about to happen in terms of the risk increases. We should all try and help identify solutions that keep the voluntary insurance market fully involved at risk there.

Now, as I mention this, there's huge developments going on in periods of low hurricane activities, and you see buildings that obviously are destroyed by storm surges, which we specifically built at a time when people didn't recognize the risk was there. We see all around the Caribbean and Florida Canal states

have been constructed in former swamplands. You'll see, here's one that is about 2 feet above sea level in the top right. One is about 4 feet, and one is about 8 feet. We should be a higher value.

There's a quote about New Orleans, is that New Orleans is the first city lost to climate change, and I've got a question mark at the end of it and a great thing to say about it. Then there's a little bit of truth in it, I wouldn't say it's 100% the case. But actually a little bit of truth about to what extent Katrina's intensity was a function of the sea level temperatures, which got some contribution from global warming in there.

The probability of New Orleans being flooded in 2006 is greater than 2%. They're not going to be increased in quality, beyond that which already existed before this year. And that's going to impact the insurance risk crisis for anybody who is going to underwrite this in New Orleans through this year, and it's going to take several years before people actually get on to of the situation to include the flood defenses. The city is thinking, at least, in places, by up to 3 feet per century. Sea levels are rising currently about 1 foot a century, and that's likely to increase. So the city of New Orleans will inevitably be lost again, even though it may be recovered now, at some point for the next 100 years it will be lost again, and it may at that point be abandoned.

Lastly, on that cheery note, planet change catastrophe risk modeling, the catastrophe risk model, is willing to consider some components of climate change where the science is there. The first model to show significant increase in risk, some components which is like this in climate change whether it's the U.S. hurricane, and that will be coming out in May next year. Other models that may come to include a planet change component, as we believe the science is there, will be some in the flood models for some regions. Thank you.

TIM WAGNER: Robert, that was absolutely fascinating. This has been so fascinating that I think some of the people are in shock. Nevertheless, Joe, if you could take it from here. Thank you.

JOE BOREN: Thanks, Tim. I have to say thanks to Robert, Evan and Markus. I just spent more time paying attention to statistics than I did in four years of undergraduate school.

This actually isn't the speech that I intended to give. I was initially scheduled to speak in September in New Orleans, and I think things have gotten a little bit more serious since then. When I spoke in Connecticut, the deputy treasurer asked me what folks sitting in the audience with the same background as I had could really do. I've thought about that question since that time, and it's a little bit like what Andrew Logan and Ceres did with AIG.

But first, I just want to tell you a little story. There's a wonderful old lady who works outside of my building in New York, and she sells pretzels. Every single day, an insurance executive would put 50 cents down on the counter and not take a pretzel. This went on for about a month. After a month, she said, "I'd like to talk to you." And he said, "I know what you want to talk about. You want to know why I come out here every day and put down 50 cents, but I don't take

a pretzel." And she said, "No, not at all. I want you to know the price is now $1."

That goes back to something I've found my whole life, and that is if you don't ask for things — no matter what your line of business is — you're not going to get them. So, to the audience, it's about asking my industry, and maybe other industries, what we're going to do about the issue of global warming and climate change.

I want to see if I can frame this issue for you in a way that's at least meaningful to me. I read something recently that Bill Moyers said, and it was something like this: That while the clock and the calendar make it seem as if our lives unfold hour-by-hour and day-by-day, our real passage is marked by events of celebration and crisis. We share all of those things in common, and they create the memories, which make of us a history and make of us a people. In my parent's generation, it was Pearl Harbor. For my generation, it was the Vietnam War and the assassinations of the Kennedys and Dr. King. For my children's generation, it will certainly be 9-11 and the scenes from New Orleans we've all witnessed.

These things change us; they change the way we think. Hopefully, they change the way we act. As Michael Berenbaum (who runs the group that works with survivors of the Holocaust) has said, the true meaning in survival is what we make of ourselves out of the ashes; how we move forward.

So, what's our role? AIG is a global company. We operate in 135 countries. We provide insurance all over the world. We don't really create greenhouse gases, but it's not lost on us that when the insurance industry, in general, speaks — and when we speak — people listen. At the very least, the insurance industry always gets its point across by excluding coverages on certain things. I think those days are past, and you really have to be far more proactive about this.

Now, to be fair — and we've listened to a lot of science —there will be those in our country who take an opposite view. Dr. Gray at Colorado State University and Bill Ladsen at NOAA, for example, think these climate patterns are based on cycles. But I want to tell you a story. This occurred to me back when I was studying air pollution control at the University of Southern California a long time ago. I'm not a very good scientist, but I met a man named Arie J. Haagen-Smit, who was a guest lecturer. People told me he was the guy who really discovered what made up smog, so I thought his lecture might be interesting. I listened to him talk about how emissions from tailpipes, combined with sunlight, created smog. After the class, I asked, "Look, how long did you take to work on that?" He said, "Years and years and years, because people thought it was nonsense when I told them that what comes out of that tailpipe combines with sunlight to create smog."

Years later, when I was working in a regulatory agency, I discovered that, in a part of the state I was working in, peoples' drinking water was contaminated. We sent engineers and hydrologists there, and they said it's coming from the landfill. I remember meeting with the mayor of that town, and he said to me, "That is not possible. The landfill is two miles away. Are you trying to tell me things that come out of the landfill are ending up in these peoples' drinking water?" And the answer was, "Absolutely." So, we had to

create a new water supply for those people. Fortunately, we didn't end up having a lot of people sick.

Why is that important? Because science sometimes doesn't resonate with the constituencies that we have to deal with. So, we have to find a way to make certain that people understand that these are important issues. And we have to cut through the science, as important as it is. There's a story in today's *Wall Street Journal* about the pollution in China. The fascinating thing about the article is that it said traces of mercury are being found in New England, and that they know it's coming from power plants in China. So this is not just a U.S. issue. This is a worldwide issue. And, it is an issue that's going to take action by everyone.

I have some interesting stats for you, sort of debunking this cycle theory, which I don't subscribe to. Seven of the 10 most expensive disasters in our history have occurred within the past four years, not all of them hurricanes. But six of the 10 most expensive hurricanes in U.S. history have occurred in the past 13 months. That's a cycle unlike any other cycle ever seen.

This is one of my more interesting slides. They're actually not my slides; they're from the Insurance Information institute, but I find them interesting. This is the total value of coastal exposure in billions; Florida's insured values are almost $2 trillion along the coast. I think you've all heard this, but you know if Hurricane Katrina had hit Miami, it would have been a $150 billion insured loss.

Why is this significant? For many reasons — and not just because insurance companies might not sell insurance — but capital, once invested, needs to be protected. If we can't protect the capital that is going to be invested, mostly through insurance, we're going to start to see displacement. We won't see areas that are growing around the coastal zones anymore. If you look at the chart, that pertains to many, many states; it's a very serious issue.

What should an insurance company do? Again, I'll talk about things we could do that impact our own footprint on greenhouse gases — but we also work in several different areas, including investment strategy, financial products, insurance products, consulting and education.

What should we do on investment? I'll tell you what AIG is going to do. There are two important features that we're going to do. The first is we'll announce soon something that looks like The Equator Principles, we'll probably call them the AIG principles for investing, to look at things and their impact on the environment. We'll also be establishing a "green fund." I know our investors always want to make sure they get a return, but there are good things to invest in; you just have to work a little harder to find them. That is what we can do with our capital, and that is very important.

The second thing we need to do is have a strategy on greenhouse gases. We believe we'll get into the emissions-trading business, mostly overseas, initially. It's much more difficult in the United States, given that we have chosen as a country to withdraw from the Kyoto Protocol. But there is a market overseas, and we're probably going to find our way into that market. We have to look at some other things, as well, on the investment side, but trading emissions will probably be an important thing.

What about insurance products? One of the things that amazed me — and I run AIG's environmental insurance company — was the lack of environmental insurance in place in New Orleans. I was amazed, given that it's a pretty competitive market in this day and age, that there is so much contamination there, and so many of the companies that caused the contamination had no environmental insurance. I don't even know if they knew that they could have had environmental insurance. We're going to have to do a better job at making sure people know they can project themselves on the environmental side through insurance.

The other thing we'll probably announce soon is some sort of insurance to guarantee the delivery of carbon credits; that's what folks in the foreign markets have been asking for. We've been working on it with one particular company and we think we're close to being able to do that. Directors and officers (D&O) liability insurance is a very interesting area. I'm not a D&O expert, but I know that, at AIG, environmental contamination under a D&O policy is excluded; we don't offer protection for that. The issue is that our company might get sued, because clients have not taken the right precautions to protect themselves, maybe because they didn't buy the right insurance and so their shareholders suffered. Or, there's nobody there to defend them when some public interest group takes action against them, because they haven't done the right things on climate change. So we're looking to our own D&O insurance company as to how best we ought to respond to that.

Finally, and Robert was really hitting on this, the models we use for property placement and property insurance, you can just throw those out. They are of absolutely no value, and new models need to be created. One of the things that will come out of this, certainly in the short run, is that insurance companies are going to offer less capacity in those areas I showed you. It's not complicated when you try to figure out how to protect yourself in Florida. The first way that people are going to think about protecting themselves — and I'm talking about people in the insurance industry — is to have less exposure in those places. We all understand that.

Consulting services. AIG's Hartford Steam Boiler company owns a company called Solomon Associates, Inc. Their whole business is to advise companies on energy efficiency and what they ought to do about greenhouse gases. They work all over the world. As I say, they've worked silently all over the world, because not a lot of people know Solomon Associates is part of AIG. That's part of our services that will continue to increase, and one that we're pretty excited about. Look for other ways to expand consulting services.

Then there needs to be a communication strategy. I, for one, don't think it's worth talking unless you have things to talk about. And, when you do talk, I think it's important to push others in for the debate. So, it's important to be here, and I thank you for the opportunity. It's important that we be at these types of events, and that we take a strong public position on this topic. We understand it may be somewhat self-serving to say we think we're the leaders in the insurance business. But we understand that when you're a leader, it requires you to wear a heavy mantel — or a heavy crown — because you have to take positions

and sometimes help foster change. That is a responsibility that comes with leadership.

Finally, we're looking inward. I made a proposal that the limited fleet we have should be a hybrid fleet. We're also looking at our own footprint, because you should always start by talking about the things you've done. So we'll look at all of those things. Now, the industry in the United States has been kind of silent on this issue until recently. I think it's important that the rest of the industry gets behind us — and get in where I started with saying that I think your role is to make sure you ask, because if you don't ask, if Andrew Logan never showed up with his group to meet with AIG executives, I don't believe we'd be where we are today. But they asked, and they pushed us. And we're starting to see some results. So, I thank you very much for giving me the opportunity to be here.

TIM WAGNER: Thank you, Joe. That was great. Next, some of you know Jack Ehnes. Jack is the former Colorado insurance commissioner, and we served together for about two years. Jack is CEO of the California State Teachers' Retirement System (CalSTRS), a large public investment pension fund. And, he's investing in a little green these days.

JACK EHNES: Thank you, Tim. I was really excited to come here and get a chance to spend a few minutes with you. I bumped into Tim at the UN conference on climate risk earlier this year, and it was really quite a seminal event. This is the second year in a row we've done this event at the United Nations. The first year we did it, the audience was primarily believers, advocates and investment industry people that had spent time thinking about this. But if you could have seen the audience this year, we had about 300 individuals, the investment companies that were there with us were the mainstays of our American and European financial markets. It has dramatically changed.

I always look back at the NAIC process with amazement and awe, and with respect to the processes we used here to navigate these complicated state regulatory systems, but you all know the time it takes to do that. We've all been frustrated at a time when there's something that needs to be done, or we see pressures from the federal government or Congress or political bodies, and you see issues before you. And you have to figure out how to navigate these state regulatory waters in some efficient manner?

Now that I've transitioned from being a regulator to an investor, I would tell you what I see from my perspective is that the financial markets and shareholders are starting to pay attention here very strongly. When I was a regulator, I didn't hear too often from shareholders on my side of regulation. But, I would say that there is a strong awakening of large institutional shareholders that will start to change how the financial markets respond to this. As regulators, it's important that you're with us all in shaping solutions.

This won't be an issue for four or five years, when certain changes start to be made. We are pressuring the SEC about the disclosures of publicly traded companies. There's no doubt shareholders will be at the table on all of these issues. I can't capsulize that for you; I know you're going to be looking at some

resolutions and some committee structures here in the coming weeks, but I would think about how to make sure that you stay in the conversation very strongly if you go forward.

Those of you that are regulators are obviously working at some type of public sector agency and you've got a public pension no doubt. I'm hoping one of the things you take back from this isn't just how investors, large institutional investors, are in the game right now, but maybe also challenging what your own state's doing with your public pension dollars. Because a whole other discussion in a whole other forum today is the viability of pension plans in America, and where they're going. A lot of this rests on our financial success with our portfolios, so this is actually a piece of that discussion, too. If you don't know CalSTRS, it is the largest teacher's retirement system in the country, the largest system in the world; as of a couple days ago, we had about $135 billion in assets.

If you haven't noticed, there are a lot of institutional investors. In fact, if you took the top 10 investors in any publicly traded company, they're usually mutual funds: Vanguard, Fidelity, Putnam, you name it. A little farther down are the public pension plans. In fact, if you took any major corporation in America between ourselves and CalSTRS in Sacramento, we probably own 1% of every company in America.

So, we have a lot of influence at the table. But, also, because of our governance structure in the nature of our portfolios — and this is something I noticed the public never really understands — the way we structure our investment portfolios in a public pension plan is dramatically different than other institutional investors. If you want to think about who is the most long-term passive investor in America, it's often the public pension plans. In fact, we often have maybe 80% of our portfolios indexed to some type of passive portfolio. The significance of the way we invest means we're long-term paths of investors; we're in it until the end, so corporate governance is very critical to us. That is what drives our activism in this area. We are in the game so long and our time horizon is so far out, so if we see problems in the financial markets, we have to be in there as advocates for change — whether it's around how to structure corporate boards, whether it's independent audit opinions that are truly independent or whether it's to make sure that corporations have assessed their liabilities. That's really our position in doing so.

Is this about a social cause or a fiduciary duty? Now, I'm out in California. A lot of people like to label that we adopt these causes, because we adopt a lot of causes in California. But I would tell you that there really is a legal fiduciary duty for those of us that are investors to make sure that we protect our investment portfolios and that we look for risks around our portfolios. Again, as a passive investor, we make sure we're in the game, being an advocate for change, for a process around looking at these things.

Now take a look at that one number at the bottom. If you don't know, an average mutual fund that probably every one of your invest in, right now, with your own portfolios, has a portfolio turnover, on average, of 100% or higher in a year. That's how much those stocks are turning in those portfolios. But with a

large institutional investor, like the public pension's plan with CalSTRS, our turnover is under 2%. So, there's a dramatically different view of how we invest.

Here, I just picked out a few companies. Take a look at that top one there; that's my investment in the fund that I manage in my colleague's company here. We have a $656 million investment in AIG. So you can be darned sure we're concerned with what's happening at the company at all levels going forward. Hartford, Prudential, Met Life, Principal, United, Allstate … these are very significant investments for us across all lines of insurance.

The other thing is that it isn't just stocks and trading that manner. As we're starting to see the impact on our financial success, we're actually driving this environmental tension; there's concern about climate risk throughout our investment portfolio. We do a lot more investments than just stocks in running a pension plan like this. So, the corporate governance program, as I mentioned to you ready, we're watching very carefully and encouraging the SEC to be far more aggressive. We do not feel investors should encourage corporations to take the steps they have to take. So we will be continually talking to the SEC about being more aggressive.

This year, we've targeted industry sectors, particularly the auto and electric utility sector, for increased disclosure around climate risks. In our public equity investment management portfolio, as you can see by these bullets, we're actually challenging our managers, actually asking our investment managers what they are doing, when looking at stocks and funds, what's been done to actually look at this type of risk. I will tell you, an investor of our size constantly ask questions of Goldman Sachs, Barclays, State Street — of all of our major business partners. We constantly ask those questions and review their performance for us in managing our assets. It starts to make a difference. It starts to ripple through the system, especially in regard to climate risk.

In our own real estate portfolio, we have about $6 billion worth of real estate. And, as you know, energy is a constant topic in California. Because we have a fair amount of real estate in California, we're promoting a lot of different programs to hopefully realize energy savings in our real estate portfolio.

One of the exciting parts of this, and obviously a scary part about this, is showing that things can get real bad if we don't take some measures to counter ozone depletion. But, as was mentioned, there is certainly opportunity in the market as we go forward. I would tell you between CalSTRS and our system, we are probably the two largest leading investors right now in the country, in the private equity market, looking at clean technology. We do feel there's a lot of interesting work being done in California in this area. So, again, we do think that adds diversity to our portfolio, and it offers a true value at these types of new opportunities.

Finally, I want to make sure you know that investors are coming together as an organized body to look at this issue. You will hear this acronym INCR, the Investor Network on Climate Risk, which is composed of U.S. and European investors. Together, we hold about $3 trillion in assets. I think you can do the math. If investors with that type of market influence come together, and we agree on an agenda here that needs to have some attention, we assume there's going to be some impact on the financial markets.

Coming out of the investor summit conference just earlier this year, we made commitments together of investing this year at least $1 billion in companies that will focus on clean technology. We're going to rank 100 of the world's largest companies and actually have a report card presentation of that. So we will give them public disclosure around who's doing a good job, and who's not doing a good job in this area. As I said, we're going to require our investment managers to describe their strategies regarding climate risk.

I recently sent a letter to 30 of the largest publicly held insurance companies in the United States requesting that they undertake a comprehensive analysis of the business implications of climate change, and make those disclosures to shareholders. Again, because these companies have diverse portfolios, we want to make sure they start looking at the same economic opportunities that we feel are available in the clean technology area. So, we will certainly be encouraging them to do that, as well.

Insurers need to incorporate climate modeling into their risk analysis, you heard that earlier today. Analyze the implication, and certainly encourage public policymakers to start to take action.

So, what are you going to do? It kind of comes back full circle. We provided a lot of information today; in fact, I'm a little worried that you may have a bit of information overload. But, all of you here in this room have a lot of opportunity to make a difference. You're the intersection of all of the different parties. In fact, when I was a regulator, I think that's what I enjoyed the most about being in the job is just the complexity of the work, the fact that you're at the intersection of the policyholders, the investors, the business side and doing the right thing for the public. This is one of those things where it really will make a difference. You can elevate standards. You can encourage the insurers to gather more information; just look at the solvency standards. And, of course, you can encourage Congress and a lot of other public policymakers that have a real stake in this to start to move forward. We do not want the public policymakers to get so far behind the market forces, and recognize that there are things they should have been doing all along to make sure that the things got where we wanted to end up.

Again, I hope we've given you a lot of good information today. Reflect on that and figure out how the NAIC fits into that, so you can be a real active partner in creating progress in this area. Thank you all for being with us.

TIM WAGNER: Thank you, Jack. Now, we have about 20 minutes left for questions and answers. This is our time with some real experts in this area in climate change, of investing and climate change, and of modeling. I want anyone that has a question to ask it.

UNKNOWN: I hope this isn't too much of a detailed item; this would be for Jack on the immediately preceding presentation. He said that on December 1, that's very recent by the calendar on my watch, that a group of investors … What group of investors asked these questions, and will the results of these questions be publicly available in any kind of a fashion? Because they wouldn't necessarily have to be publicly available.

JACK EHNES: The group of investors, you know, is meant to be a composite group. It's a group of a lot of state governments, state treasurers or state controllers, state public pension funds, labor funds. It stems from that body of activist organizations that were involved in the United Nations summit that are continuing to look at the area. Certainly, the information — because it's meant to be shareholder-focused — by definition, it's going to be public. The purpose of that was from our perspective was to get the ball rolling specifically around that request, but not in any way to be exclusive in doing so. So, there's absolutely a public quality about it.

UNKNOWN: I have a question for Dr. Mills. In the Ceres paper that was released, one of the themes, one of the issues, that I think was tackled, is the question about how much of the increased losses are due to demographic change, increased value, increased population on the coast versus climate warming. I just want to make sure that I was getting the right message in the paper, or at least the assertion being, that yes, a lot of it is the demographic change, population, increased value, but you don't believe that companies or insurers should be ignoring the climate change factor. I wonder if you could dig down in that a little more. There wasn't really any quantification between the two, and maybe that's one of the ultimate questions here.

EVAN MILLS: Yes, it is. In fact, no one has adequately quantified this issue. There are spot studies on specific hazards in specific areas and specific countries, and they are often inappropriately used to make broad-brush statements to dismiss any role for climate change in the observed trends. There is no global view, there is no thorough view, especially on this whole class of small-scale events. So, there is no definitive number as of yet, but we know from looking at the overall indicators, like the chart I showed, that less than a quarter of those losses is explained by the growth trends in inflation, and population insurance premium growth. It's interesting to look at that with the non-weather-related trend next to the weather-related trend, and to see that they're dramatically different. The weather-related losses (the red curve) would have been much higher if the building codes had not improved since the 1980s.

TIM WAGNER: Thank you. I'll ask a question that really kind of cuts to the quick, and it's a scary one. As you see climate change evolving, can the private industry continue to finance risk at affordable rates? Will the public sector be tolerant of financing that risk at an affordable rate? And, I think we heard from Robert that we're going to see some major changes in the way we build, where we build, what we build … Does anyone want to take a shot at that aside from Robert?

UNKNOWN: Yes. I would say, we're not at this point now, but to the extent that this dialogue continues, and we end up in a situation (INAUDIBLE) electric, say on the utility side, the energy sector, to the extent the companies' behaviors are responsible here and don't get (INAUDIBLE) capital. There's no doubt about that. Just as the tobacco industry has lost favor with a lot of

investors because of the liability issues. (INAUDIBLE) a lot of students that really do not take seriously their responsibility (INAUDIBLE). That's why, I'm hoping (INAUDIBLE) marketplace is such a powerful tool, and also being a judge of (INAUDIBLE) who's not (INAUDIBLE).

UNKNOWN: In the study that came out a few weeks ago, we did present some scenarios and I—in this kind of space, I'm more interested in scenarios in the forecast. You ask a question: Will it or won't it? And it depends, of course, on the types of responses that we all have, meaning insurers, the regulators, etc. And there, of course, good and bad scenarios, but there are very good ones that are possible — meaning that there are things we can do to maintain insurability, spread the risk more widely, also helping to keep the insurance market vibrant and keep it affordable. But the business as usual … If you will, the answer would be yes, to your implied question, that we're going to (INAUDIBLE) scope of insurance. And I don't think that's (INAUDIBLE) or the buyer's. This is a—(INAUDIBLE) letter (INAUDIBLE) investor letter (INAUDIBLE) sent to various institute. What was that, a few weeks ago (INAUDIBLE).

UNKNOWN: I had to leave right during the middle of this, but I watched the first several presentations and the last, and what I saw as a recurring theme, was we had problems with the insurance industry data. By profession, I'm an actuary, and end up dealing with data. And I know how sometimes the data might be there, but it's just a matter of how much money and effort you're willing to spend to extract it from the system. I saw this as a recurring theme. Could you, whoever feels most comfortable, expand upon the types of data you feel the industry is most efficient in collecting, or where the biggest problems are? Or is it just a matter of there isn't enough interest for them to spend the money to extract the data from what they already have.

EVAN MILLS: I'll take a first crack, and hopefully we can hear from some others. One acute need is to begin collecting data for events with loss costs below the $25 million threshold for data currently collected by the insurance industry's PCS. There are billions, probably tens of billions of dollars involved, and we don't know anything about their composition or trends because the data aren't collected. We need to know much more about the health-related consequences of climate change. Take, for example, heat catastrophes. We know reasonably well how many people die in these catastrophes, but we don't know the hospitalization rates and costs, partially because it's very subjective and difficult. Another example would be vehicle accidents due to inclement weather.

TIM WAGNER: I might respond a little bit to that, Evan. Simply, the private sector, particularly the regulated private sector, and the health business is becoming smaller and smaller as the public sector grows, and the risk of its plans continue to evolve. So, we may have to focus on HHS-type entities to get some of that information. Are there any other individuals that have a question? I guess not.

I'd like to give a preview of what our next step is, so you can understand a little bit about what we're doing. The Property and Casualty Insurance (C) Committee will meet Tuesday morning. There are two things on the agenda relating to climate change. The first is a resolution to Congress from the NAIC notifying Congress that climate change is occurring, that it is affecting the insurance industry and that we have concerns. We're asking Congress to take some steps to become more participatory, if you will, and put some controls or limitations on carbon emissions. I don't know where that will go within the committee, and I don't know where that will go within the NAIC. But we are going to expose a resolution on that issue.

The second thing that we're going to discuss in the C Committee is whether there should be an Executive (EX) Committee-level task force dealing with the issue of climate change. Because of Hurricane Katrina, the Property and Casualty Insurance (C) Committee is at least three months behind where we thought we would be. But we'll discuss whether the Committee should recommend to the Executive Committee, to the officers, that we have an Executive Committee-level task force. The reason being that there are some life issues, there are some health issues and, clearly, there are investment issues — so its effects transcend the entire insurance industry, not simply the property and casualty industry. So, we will be discussing those points in the C Committee meeting on Tuesday.

Would anyone else like to comment? Evan.

EVAN MILLS: Just to pick up on some things you just said. I see on the agenda that there are several sessions here this week on international issues. I encourage the NAIC to also think about vulnerability assessments for American writers who are increasingly going into offshore markets. You think of developing countries and those markets have more vulnerability to climate change, no building codes, no evacuation plans, no communication systems. And they have, in some cases, higher weather exposure, more agricultural dependence, more coastal development. If insurers are doing business in one of those markets, then their surplus is exposed in some fashion. So, I'd encourage you to add that to NAIC's agenda for studying the relevance of climate change for insurers.

TIM WAGNER: We will take that into consideration. Are there any comments from the audience? No. Any comments from the panelists? If none, we're adjourned. Thank you. You've done an excellent job.

*** END ***

Availability and Affordability of Insurance under Climate Change: A Growing Challenge for the United States*

Evan Mills, Ph.D.
Richard J. Roth, Jr.
Eugene Lecomte

This report was commissioned by Ceres, a national coalition of investors, environmental organizations, and other public interest groups working with companies to address sustainability challenges such as climate change. Helpful comments were provided by Tim Wagner (Nebraska Insurance Director), Nettie Hoge (California Insurance Commission), Richard Roth, Sr., Nancy Skinner, and Andrew Logan. The opinions expressed herein are those of the authors.

www.ceres.org

About the Authors

Dr. Evan Mills is a scientist with the U.S. Department of Energy's Lawrence Berkeley National Laboratory where, for the past 10 years, he has led a research initiative on insurance loss prevention. He served as co-leader of the 2001 Intergovernmental Panel on Climate Change (IPCC) analysis of the potential impacts of global climate change on the financial services sector. He has published 50 articles and reports on the subject, including a recent essay in the journal Science.

Richard Roth, Jr. Mr. Roth specializes in the financial examination of insurance companies, reinsurance, workers compensation, automobile insurance, and insurance against natural hazards. He was Chief Property and Casualty Actuary for the Department of Insurance, State of California, for 20 years, and Assistant Commissioner from 1984 to 1990. He is now associated with Bickerstaff, Whatley, Ryan & Burkhalter, a leading actuarial consulting firm in the United States and internationally. He served as Chairman of the Casualty Actuarial (Technical) Task Force at the NAIC, and was active on the two catastrophe insurance committees addressing catastrophe insurance issues for all types of insured natural disasters. Mr. Roth served on the Board of Directors of the Casualty Actuarial Society twice. This is an elected position by the members of the Casualty Actuarial Society. He has been one of the delegates representing the Casualty Actuarial Society to the International Actuarial Association. He has testified on natural disaster and earthquake insurance before the California Legislature numerous times and before the United States Congress three times on earthquake insurance issues.

Eugene Lecomte is President Emeritus of the Institute for Business and Home Safety, Boston, Massachusetts. A veteran of more than fifty years in the insurance business, Mr. Lecomte has served as President and CEO of the Insurance Institute for Property Loss Reduction, the National Committee on Property Insurance, and the Property Insurance Plans Service Office. He also served as President of the Massachusetts Automobile and Workers Compensation Rating Bureaus, and The Earthquake Project.

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* This paper was submitted for the NAIC public hearing, "The Implications of Climate Change on Insurers and Insurance Consumers," which was held during the 2005 Winter National Meeting. It accompanies the remarks made by Dr. Evan Mills in the transcript of the public hearing.

Foreword

This white paper was prepared by a three-person collaboration that included a scientist, an insurance actuary (who also served as a regulator), and an insurance veteran of 50 years. The paper explores the insurability of risks from climate change, and ways in which insurance affordability and availability could be adversely impacted in the U.S. i n the coming years. It includes examples where affordability and availability of insurance are already at risk from rising weather-related losses and how future financial exposure for insurers, governments, businesses and consumers could worsen if current climate and business trends continue. The paper, which includes specific recommendations for addressing this growing insurance challenge, was published in advance of the National Association of Insurance Commissioners Winter 2005 national meeting, at which NAIC will examine the implications of climate change on the industry. NAIC's web site recently stated:

> *It has become evident that climate change will continue to challenge insurers and state insurance regulators. Inevitably, this will pose a threat to the availability of essential insurance coverages for consumers.**

Work on this project began shortly before Hurricane Katrina struck New Orleans and the broader Gulf region in late August 2005, and was completed in the days immediately following the horrific event. The full extent of the losses will take months to be known, but this historic loss event will clearly create an intricate web of impacts on almost all lines of insurance and additional economic impacts spilling over into the broader economy. Immediately apparent impacts include loss of 150,000 houses, major crop losses and disruption of agricultural exports, temporary loss of 95% of the region's oil production as well as interrupted foreign oil imports, elevated national and international energy prices, demands for tens of billions in federal disaster relief, and widespread environmental contamination. By many measures—including loss of life—the impacts of Katrina will dwarf those of 9/11. One thing is certain: losses will be spread widely, with insurer exposures limited. The federal government, with 377,000 flood insurance policies in force in Louisiana alone, will have large numbers of claims through the National Flood Insurance Program (which provides $52 billion of coverage in Louisiana) and broader disaster relief efforts. As there are renewed calls for a national reinsurance backstop for catastrophes, both FEMA and the NFIP will likely have to obtain new funds from the Treasury to compensate for insufficient reserves. Most low-income households will face the difficult circumstance of having no insurance at all. Katrina reminds us that massive loss of life from disasters is not limited to natural disasters in the developing world. Katrina also renews discussion about the influence of climate change on hurricanes. While some have made too much of the connections, others are all too eager to downplay it. Recent scientific work has established new linkages between rising sea-surface temperatures and the power of hurricanes,[1] yet much more work must be done to understand the details.

* NAIC also published an article entitled "Insurers in the Greenhouse" in their *Journal of Insurance Regulation*, prepared by E. Mills, E. Lecomte, and A. Peara. Vol 21, No 1. (Fall 2002).

Key Findings

History has shown that insurers and their customers can be adversely affected by weather extremes. **Catastrophic weather-related insurance losses in the U.S. are rising significantly faster than premiums, population, or economic growth, and many smaller events are not even included in official totals** (Figure 1). Even before Hurricane Katrina such events are were already being felt in parts of the country, and **if trends persist, the impacts of climate change in the United States—which scientists believe is being caused primarily by human activities—will inevitably result in more insurance claims and increased costs. These higher losses, in turn, will lead to higher premiums and deductibles, lowered limits, and broader coverage restrictions.** The convergence of climate change with demographic and socioeconomic trends, such as the tendency for people to move to high-risk areas, will further compound the impacts. Events of concern include floods, windstorms, thunderstorms, hail storms, ice storms, wildfires, droughts, heatwaves, lightning strikes, subsidence damages, coastal erosion, and airborne allergens (e.g., mold and pollen). Most insurance lines are climate-sensitive, although certainly to varying degrees.

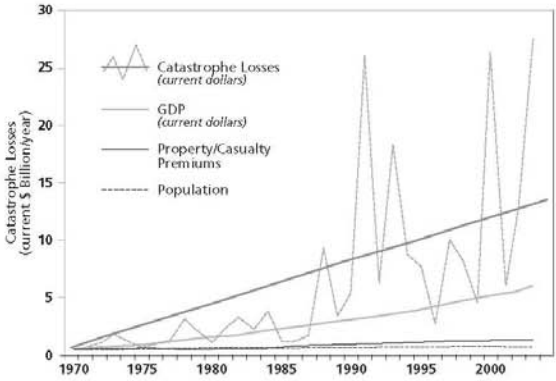

Figure 1. U.S. Catastrophe Losses are Growing Faster than Premiums, Population, or GDP. Since 1971, U.S. catastrophe losses have grown ten-times faster than premiums. More disconcerting, the losses shown above do not include thousands of small events each year not considered catastrophic. The same trend can be seen globally (Mills 2005). Non-weather-related losses have risen much more slowly than weather-related losses. In the figure, GDP, population and premiums are indexed to the 1971 losses to facilitate comparison. Loss cost, premium, and GDP data reflect values in year incurred; relative changes are unchanged if inflation-corrected.

Climate stresses will also place more political and financial burden on reluctant federal and local governments as they assume broader exposures and become insurers of last resort. The most recent example is renewed calls in the wake of Hurricane Katrina for the federal government to establish a national catastrophic insurance fund, essentially a reinsurance backstop to safeguard private insurers.[2] Governments also are compelled to address events for which there is no insurance at all, while paying for disaster preparedness and recovery operations. A recent example of this: federal and local governments are incurring substantial liability and expenses due to landslides in southern California, with losses averaging $100 million per year.[3]* Business and consumers will be burdened as well because cash-strapped governments generally cap paid losses and shift greater portions of risk back to consumers.

* There have been occasional and minimally-subscribed private insurance offerings for landslides in California, priced several times higher than comprehensive homeowners insurance (and must be purchased on top of that insurance), with exclusions for neighborhoods that have experienced landslides in the past.

Risk sharing by consumers is certainly appropriate, to a degree, insofar as it encourages responsible behavior and loss prevention. Given the critical role that insurance plays in the U.S. and global economy, reduced access to affordable insurance would have profound impacts on both consumers and businesses, whether from reduced access to basic mortgage financing or loss of business-interruption insurance for offshore oil rigs.

Some of these far-reaching impacts are already taking place. In Florida, the wave of hurricanes in 2004 prompted substantial rate increases, despite which seven private insurers stopped writing homeowners policies in the state or withdrew from the market altogether.* The effects of Hurricane Katrina will be even more significant than last year's four hurricanes combined. Meanwhile, government-provided crop and flood insurance programs are seeing rising losses, wildfire events are causing two times more damage compared to a few decades ago, and coastal erosion hazard insurance is entirely unavailable. The latter issue is an especially acute concern because climate change is expected to cause a twin combination of sea level rise and stronger storm surges, a direct physical threat to many coastal properties in the U.S..

Yet, despite these emerging challenges, climate change has received relatively little attention to date in the United States from government, insurers, and regulators. Although we are witnessing a precipitous rise in weather-related losses in the U.S., and numerous projections that climate change will likely magnify those losses in the years ahead, only a small fraction of potentially impacted U.S. insurance companies have seriously examined the business implications of climate change, and fewer still work closely with climate scientists or present their analyses publicly. Nor has the U.S. government assessed its full financial exposure from weather-related disasters (e.g., as crop and flood insurer, provider of disaster recovery, or owner of at-risk infrastructure). Remarkably, the world experiences a "9/11" each year in weather-related catastrophes, yet the issue receives only a tiny fraction of the attention as does the problem of terrorism. In Nebraska, hailstorm losses alone are more costly on a per-capita basis than New York's losses from 9/11.[4]

Widespread data gaps and limited computer modeling capabilities are also hampering the industry's ability to respond. Insurers and their regulators as yet have no comprehensive capacity to assess the cumulative weather-related risks from both catastrophic events and the growing number of small-scale events.

It is incumbent on insurers, regulators, policymakers and other stakeholders to develop a better grasp of the physical and business risks from the climate change issue. With improved intelligence, the private sector will be able to better address potential market failures and thus reduce economic fallout on insurers of last resort (local, regional, and national governments). Tackling this challenge will require unprecedented cooperation and collaboration among various stakeholders (insurers, their regulators, governments, scientists, and insurance customers). Each group can bring valuable insight and talent to assessing the risks and implementing appropriate loss-prevention measures. This has precedent. Devastating earthquakes in California prompted a far-reaching, positive collaboration in the 1980s among state and federal regulators, engineering firms, earthquake scientists and other parties to better manage earthquake exposure and its potential impacts on the industry. These efforts improved the technical ability of the state insurance regulators to supervise earthquake insurance companies.

We recommend the following actions by these key players:

Insurers

- Strive to improve loss data collection and actuarial analysis
- Analyze implications of climate change on their business and investments, and share the results with shareholders

* It is not appropriate to associate any single event with climate change. Climate is the long-term average of weather, and so it is the broader trends in weather events where climate change leaves its fingerprints.

- Strive to increase use of risk management
- Encourage policy action and technical measures to achieve greenhouse-gas emissions reductions, especially where there are collateral benefits to the insurance core business
- Engage in weather/climate science and promote the use of scientific methods and climate-modeling
- Reconstitute something along the lines of the climate change insurance working group that was active in the mid-1990s*

Insurance Regulators

- Review the "standards of insurability" to identify new challenges, domestically and abroad
- Incorporate climate risks in solvency and consumer-impact analysis
- Encourage insurers to collect more comprehensive data on weather-related losses
- Elevate the standards for catastrophe modeling
- Assess exposures of insurer investments and adequacy of capital and surplus to weather extremes
- Explore the feasibility of developing a catastrophe exposure questionnaire similar the California Insurance Department's annual Earthquake Questionnaire

Governments

- Foster and participate in public-private partnerships for risk spreading
- Enhance adaptive capacity through planning and disaster response
- Take policy action to reduce greenhouse-gas emissions
- Reduce vulnerability to disaster losses
- Promote basic research on climate change and loss modeling, and issue climate change hazard maps
- comprehensively assess the government's overall financial exposure to weather disasters

Consumers

- Minimize disaster losses through the use of recognized pre-loss mitigation practices
- Curb emissions that cause climate change, primarily by enhancing energy efficiency and increasing the use of carbon-free energy sources

Insurers and their regulators need to be more than fair-weather friends with regard to climate change. A key next step is to develop a better understanding of the exposures faced by various groups and the potential physical and market consequences for the industry and its vast customer base. The task is surely daunting, but not nearly as much as coping with the impacts of a business-as-usual scenario.

Overview

At various points in history, insurers have encountered changes in their market environment that have precipitated structural shifts in their industry and the broader societal handling of risk. The great dust bowl of the 1930s challenged crop insurers, urban riots of the 1960s challenged property insurers, and today terrorism simultaneously challenges multiple insurance lines, ranging from workers compensation to business interruption to political

* Members included The Alliance of American Insurers, American Insurance Association, The Insurance Institute for Property Loss Reduction, National Association of Independent Insurers, National Association of Mutual Insurance Companies, Reinsurance Association of America, and State Farm Insurance Companies. A letter from this group to then Vice President Gore is reproduced as Appendix F in Mills *et al.* (2001).

risk. The Great Midwest Flood of 1993, Hurricane Andrew in 1992, and the Northridge Earthquake of 1994 brought natural disasters to the fore and led to fundamental problems of affordability, exclusions, and insurability. They also repeatedly brought home the fact that the past is no longer a predictor of the future. These events resulted in establishment of public-private programs, and the advent of many proactive responses such as improved catastrophe modeling and a host of loss-prevention activities. They also led to greater (and not always welcome) retention of risk by consumers and businesses (e.g., by shifting from fixed to percentage deductibles). The effect of such changes is substantial. In Florida, 15 to 20 percent of the losses from the 2004 hurricanes were borne by consumers.[5] These historic events all have a common element of surprise: they were not believed possible. Most recently, the Department of Homeland Security stated that the scale of Hurricane Katrina was beyond anything his department could have anticipated.[6]

First recognized by insurers in 1973,[8] global warming and climate change are expected to increase the damages from natural disasters, according to the latest International Panel on Climate Change (IPCC) assessment. The problem centers on a build-up of gases like carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons caused by fossil-fuel burning, industrial activity, certain agricultural practices, and deforestation. A key result is an increase in land and sea temperatures with numerous consequences for human settlements. Atmospheric levels of the most critical greenhouse gas, carbon dioxide, are projected to double from their pre-industrial levels within the first half of this century.[9]

Global climate change will present further challenges to many insurance lines. A recent report by the Association of British Insurers (in collaboration with two of the "big-three" U.S. CAT modelers, AIR Worldwide and RMS), stated that rising carbon dioxide emissions could increase average annual losses from the three major types of storms that affect insurers—US hurricanes, Japanese typhoons and European windstorms—by $27 billion a year, a two thirds increase, by the 2080s. The report cited recent scientific evidence suggesting that rising greenhouse gas levels and rising temperatures will boost the energy of the earth's weather, resulting in stronger storms. The report stated that US hurricanes could exhibit wind speed increases of up to six percent, enough to boost a Category 4 hurricane to a Category 5. Losses from more rare and extreme US hurricanes under climate change could increase by $41- 62 billion above present-day losses of $60—85 billion (for 100- and 250-year events, respectively), representing a 70 to 75 percent increase, equivalent to an additional two to three Hurricane Andrews in a single season (2004 prices and exposures).[10] Losses under a low-emissions scenario were only one-fifth those of high-emissions scenario.*

Current-day concerns include events ranging from large scale and abrupt hurricanes to diffuse and gradual impacts such as coastal erosion or moisture damage in buildings. In both cases, insurance systems have encountered difficulty in responding, often needing to raise prices and in some cases exclude risks. While more captivating, large catastrophic events cause less damage in an average year than the aggregated impacts of relatively small events (a 40/60 ratio globally). While these smaller events are less consequential for the largest insurers, they can have significant adverse effects on state and regional insurers.

In some cases, the consequences range from affordability problems for consumers and not-always-welcome expectations on governments to pick up the tab. As a case in point, although awarded significant premium increases in the wake of major hurricane losses in 2004, seven private insurers in Florida have decided to stop writing new homeowners policies or even exit the market.

The advent of publicly-operated insurance FAIR Plans (Fair Access to Insurance Requirements) and Windstorm Plans shows rising risk and inadequacy of traditional insurance loss-spreading approaches.* As a case in point, the Massachusetts Property Insurance Underwriting Association (or Massachusetts FAIR Plan—homeowner and commercial lines) has

* These cases represent atmospheric carbon-dioxide concentration increases of 40% and 116% from today's levels, to 525 ppm and 810 ppm, respectively.

become the largest residential insurer in the Commonwealth, with ~$200 million in premiums. To manage growing risks of hailstorms, mandatory percentage deductibles of up to 5 percent of insured values have recently replaced traditional fixed-dollar deductibles. Similarly, a new state-run company is Florida's second largest provider of insurance. A similar situation is underway in Texas, where escalating water-damage losses in recent years have prompted dozens of insurers to pull out of the market. Government-provided insurance systems (flood and crop) are seeing rising exposures and losses as well.[11] Although higher than market averages, FAIR Plan premiums are often inadequate to cover losses, resulting in assessments against private insurers.

Weather-related losses and associated liabilities are material risks for insurers in three ways: through their core business, the weather-sensitivity of their investments, and via indirect economic impacts of extreme weather and consequent effects on consumer purchasing of goods and services, including insurance. The Insurance Information Institute has shown that U.S. insurers' financial performance is more sensitive to energy price shocks and general economic slumps (both of which can be precipitated by extreme weather events) than the economy as a whole.[12] Insurers are also vulnerable to the causes of climate change, e.g. increased flood risk due to deforestation, and deterioration of respiratory health due to local air pollution resulting from fossil-fuel combustion as well as greater production of pollen in a CO_2-rich atmosphere.

Globally, the number of weather-related events, the variability of total losses, and the economic impacts and demographic drivers are all on the rise.[13] Insured and total property losses ($45 billion and $107 billion in 2004, respectively) are rising faster than premiums, population, or economic growth both globally and in the U.S. (Figure 1). Globally, inflation-adjusted economic losses from catastrophic events rose by 8-fold between the 1960s and 1990s and insured losses by 17-fold.† The insured share of total economic losses from weather related catastrophes is also rising, from a negligible fraction in 1950s to 25 percent in the past decade. The ratio has climbed more quickly in the US, with more than 40 percent of total disaster losses insured in the 1990s.[14]

Inflation-corrected weather-related losses in the U.S. property-casualty sector have risen from a few billion dollars per year in the 1970s to $15 billion per year in past decade, punctuated by three peaks of over $25 billion/year and a record high in 2004 that included $30 billion in hurricane losses alone. Important for insurance, unpredictability has increased as well. Weather-related economic (insured plus uninsured) losses from the subset of events with over $1 billion in insured losses totaled $486 billion, of which $172 billion were insured (inflation-corrected to 2004 dollars) (Figure 2). The annual average rate of loss rose from $3 billion per year in the decade 1950-1959 to $30 billion per year in the most recent decade (Figure 3). Averaged over the past 55 years, weather-related events have been responsible for 93 percent of all catastrophe events, 83 percent of the economic damages of natural disasters, and 87 percent of the insured losses.

* These so-called "Residual Market Mechanisms" aim to make insurance available to those who have been unable to gain it through the voluntary market, and involve various combinations of public (State) financing and allocation of premiums and liabilities to all insurers in a given market. Today, they serve about 1.5 million policyholders and represent $345 billion in exposure. For a good primer, see Insurance Information Institute, http://www2.iii.org/media/hottopics/insurance/residual/

† Natural hazard statistics and losses from Munich Re, NatCatSERVICE,

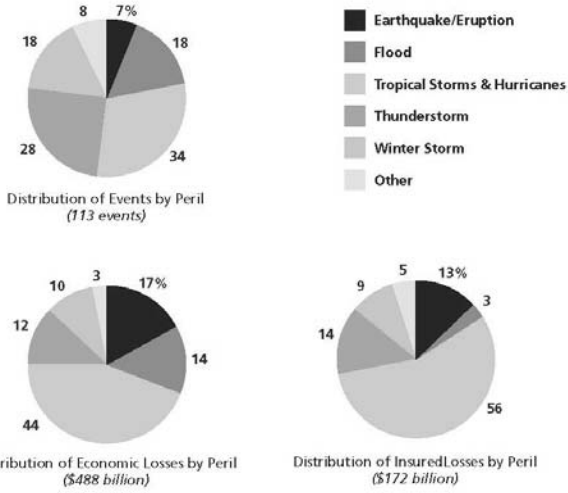

Figure 2. Weather-Related Catastrophe Losses Dominate. Represent 93% of Events, 83% of Total Economic Costs, and 87% of Insured Losses. Includes only events with $1 billion or more in insured losses. Source: Am Re 2005.

The full extent of weather-related insurance losses is not known, and only 40 percent of known losses arise from headline-catching disasters. While natural disasters are seen as the primary cause for 7 percent of insurer insolvencies in the U.S., an unspecified additional number involve catastrophes as a contributing factor to primary causes such as mismanagement.[15] Unpaid claims from insolvent insurers are typically recouped from other insurers in the market via Guaranty Fund mechanisms.

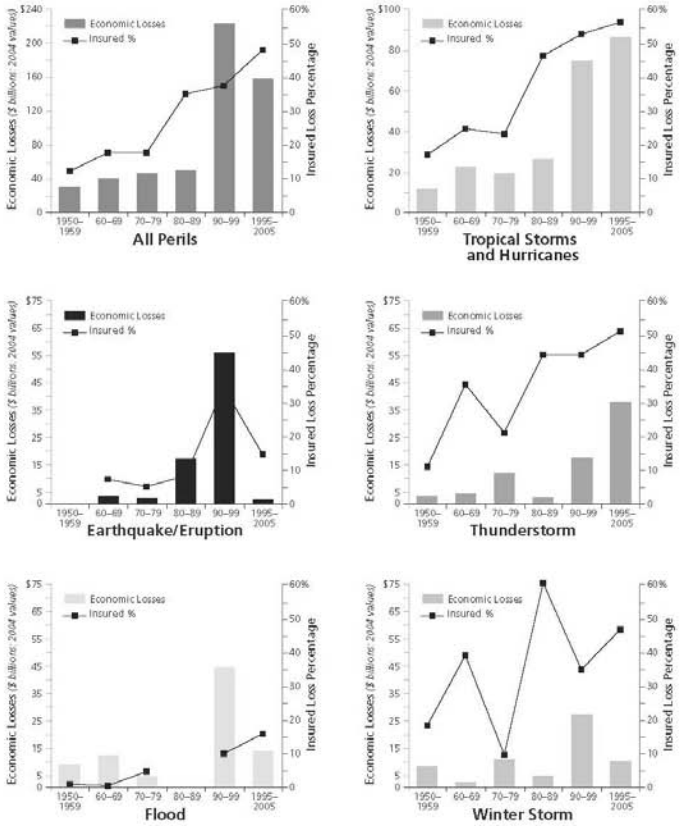

Figure 3. Rising U.S. Economic and Insured Losses from Natural Disasters. Includes only events with $1 billion or more in insured losses. Source: Am Re (2005).

Weather catastrophe losses have a visible adverse effect on U.S. insurers' combined ratios (profitability) (Figure 4). **This class of losses has not only risen significantly more quickly than premiums, but has become more unpredictable.** As insurers from the U.S. and other industrialized countries race to develop footholds in the rapidly growing emerging markets (e.g. India and China) they also assume the weather-related risks there.[16] A statistical review by Swiss Re found that foreign insurers' growth in emerging markets averaged more than 20 percent per year during the nineties.* During the late 1990s, the U.S. was leading the way,† with its primary insurers collecting approximately $40 billion in premiums for policies placed overseas, with an average annual growth rate of 10 percent between 1990 and 1998.[17] For example, rising catastrophic losses was among the reasons that one of the largest U.S. insurers

* Foreign insurers participate either by establishing local offices or purchasing an interest in local insurers. Examples of the latter include Liberty Mutual's acquisition of the Venezuelan insurer Seguros Caracas; ING's 49 percent acquisition of Sul America, Brazil's second-largest carrier; MetLife's $962 million acquisition of Mexico's largest life insurer; Aseguradora Hidalgo SA, and Citigroup's $1.24 stake in Mexican life insurer Seguros Banamex Aegon and Mexican pension-management company Afore Banamex Aegon (Ceniceros 2003; Pilla 2002).

† Notably: Aetna, AIG, CGU, Chubb, Cigna, Metropolitan Life, New York Life, and Prudential (Swiss Re 2000).

(CNA) withdrew from all overseas reinsurance business.[18] With growth rates triple of that in industrialized countries, premium volumes from the developing world will represent half of the global total in the next few decades. With their lack of disaster-resistent infrastructure, high dependence on agriculture, and other factors render these markets vastly more vulnerable to the costs and other impacts of climate change.

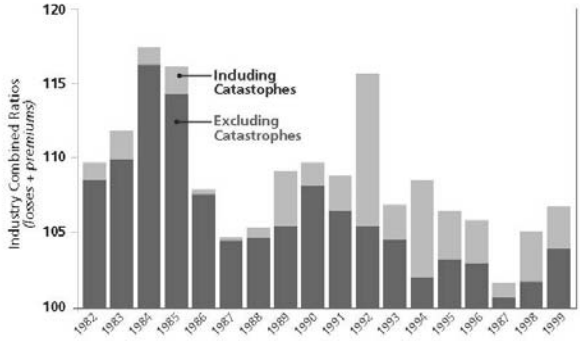

Figure 4. Insured Catastrophe Losses Impact Industry Profitability: 1982–1999.
Natural catastrophes are a major challenge to overall insurance industry profitability in the U.S. The role of catastrophe losses in U.S. property/casualty insurance sector profitability: 1989–2000. A measure of industry financial performance, the "combined ratio" is the ratio of losses plus expenses to premiums. Thus, an underwriting profit occurs when the ratio is less than 100. Including all weather-related events would increase the relative contribution of weather to the combined ratio, perhaps considerably. The combined ratio does not include investment income, which can compensate for underwriting losses when market conditions are good.

Individual insurers from four continents have organized under the United Nations Financial Services Initiative, expressing concern about climate change, including firms from Australia, Austria, Canada, France, Germany, Italy, Japan, Netherlands, New Zealand, Norway, Russia, South Korea, Spain, Sweden, Switzerland, Thailand, and the United Kingdom. Some US insurers and other industry players have also expressed concern, while in a brief paper prepared in 1999 the American Insurance Association viewed it as a relatively minor issue.*[19] With the exception of the AIA, no U.S. primary insurance trade associations have taken public positions or made recommendations. In the mid-1990s, however, US insurance industry leaders and several trade associations† issued a letter to US Vice President Gore in which they recognized that climate change was an issue for their industry and pledged to explore it more fully.[20] However, no subsequent communiqué was issued from this group and it appears that few insurers or regulators have considered this in depth. This may be changing, as exemplified by NAIC's new initiative in this area.

While often asked, it is a bit of a red herring to pose the question as to whether it is demographic/socioeconomic trends or climate change that underlie the clear and significant

* At the time, AIA estimated that about 20 percent of U.S. insurance P/C premiums are associated with types of insurance with "significant" exposure to weather–related loss, 2 percent with "moderate" exposure, 66 percent with "minor" exposure, 9 percent with "minor to no" exposure, and 4 percent with "no" exposure. The large "minor" category is primarily auto insurance, which may have more vulnerability than assumed by AIA (see Figure 13). The paper did not evaluate other measures of vulnerability, such as profitability, solvency, or exposures according to other metrics; e.g., total insured property values for which the at-risk insurers are responsible. Effects of higher prices or reduced availability on consumers were also not evaluated.

† The signatories included The Alliance of American Insurers, American Insurance Association, Insurance Institute for Property Loss Reduction, National Association of Independent Insurers, National Association of Mutual Insurance Companies, Reinsurance Association of America, and State Farm Insurance Companies. This letter is reproduced as Appendix F in Mills *et al.* (2001).

upturn in insured losses from extreme weather events. The observed upward trend in losses is consistent with what would be expected under climate change and with demographic factors. We believe that both factors are at work, with undesirable compounding effects (Box 1). Efforts to understand the relative roles of the two factors are important, and yet very incomplete at present.

As many U.S. corporate leaders have said in other arenas, "you can't manage what you don't measure." This adage certainly holds true in the case of preparedness for extreme weather events. **While the collection of loss data is better today than in the past, there are huge gaps.*** In particular, the insurance industry's Property Claims Services (PCS) database excludes from the definition of "catastrophe" an unknown number of "small" events (i.e., those with under $25 million in insured losses). Among the types of events often excluded, power outages in the United States alone are estimated to result in a cost of US$80 billion per year[21] and lightning strikes cause billions of dollars of losses each year.[22] In the case of wildfires, the PCS database contains 16 catastrophic wildfires spanning the past three decades, whereas there have been many tens of thousands of smaller fires. The result can even be that entire classes of events expected to worsen under climate change (e.g., lightning or subsidence) are virtually invisible in the data. Lacking a comprehensive grasp of the historic trends, it is difficult to prepare for the future. Similarly, catastrophe models only address a subset of the types of insurance losses expected under climate change. In addition to being able to estimate hurricane losses in the future, it is also important to know the effect of changes in inclement weather on motor vehicle accidents and lightning strikes, the melting of permafrost on insured infrastructure, or the effects of increased pollen on respiratory health costs. The combined effect of this lack of modeling and analysis means that even if insurers are interested in the issue, they cannot be expected to measure and manage their risk adequately.

The Erosion of Insurability

Not all risks are commercially insurable. A variety of definitions of insurability are found in the literature that differ in detail but share the common theme of accepting or rejecting risks based on the nature of each risk and the adequacy of available information . The insurability of natural disasters and extreme weather events may be affected by increases in the frequency, severity, or unpredictability of these events.

In essence, private insurers require that a series of conditions be met before they will assume a given risk or enter a given market. These conditions—sometimes referred to as "Standards of Insurability"—are intended to assure the insurers' financial survival in case of catastrophic losses. Risks must be estimable and manageable yet random and sufficiently broadly spread by the population of those with insurance. Prices must be set via actuarial processes, be affordable to consumers, and moral fraud and complacency must be controllable. This process involves technical and subjective judgments, and history shows that insurers will relax the standards when investment profits are high. However, a worrisome situation arises when the "perfect storm" of large catastrophic losses coincides with a downturn in financial markets (whether or not there is a causal connection between the two events).[23]

Perhaps counter-intuitively, as societies develop they can become more vulnerable to certain extreme weather impacts. For example, where once hurricanes did little damage until making landfall, it has been clearly evidenced of late that massive losses can occur to offshore oil production facilities. Very preliminary estimates place Hurricane Katrina's damages to offshore oil infrastructure at more than three-times that of Hurricane Ivan ($2.5 billion) the year before.[24] Intensifying reliance on electricity, and expansion of the electric power grid is another source of vulnerability

* The retiring president of Sorema made this point strongly in his retirement speech, entitled *"Reflections On The Future—Climate Change And Its Impacts On The Insurance Industry"*

Climate change presents various challenges to insurability. These include:

Technical Risks

- Shortening times between loss events, such as more hurricanes per season
- Changing absolute and relative variability of losses,
- Changing structure of types of events,
- Shifting spatial distribution of events,
- Damages that increase exponentially or nonlinearly with weather intensity*
- Widespread geographical simultaneity of losses (e.g. from tidal surges arising from a broad die-off of protective coral reefs or disease outbreaks on multiple continents),
- Increased difficulty in anticipating "hot spots" (geographic and demographic) for particular hazards,†
- More single events with multiple, correlated consequences. This was well evidenced in the pan-European heat catastrophe of 2003—where temperatures were six standard deviations from the norm.[25] Immediate or delayed impacts included extensive human morbidity and mortality, wildfire, massive crop losses, and the curtailment of electric power plants due to the temperature or lack of cooling water, and
- More hybrid events with multiple consequences (e.g. El Nino-related rain, ice storms, floods, mudslides, droughts, and wildfires).

Market-based Risks

- Historically-based premiums that lag behind actual losses,
- Failing to foresee and keep up with changing customer needs arising from the consequences of climate change,
- Unanticipated changes in patterns of claims, and associated difficulty in adjusting pricing and reserve practices to maintain profitability,‡
- Responses of insurance regulators.[26]
- Reputation risks falling on insurers who do not, in the eyes of consumers, do enough to prevent losses arising from climate change, and
- Stresses unrelated to weather but conspiring with climate change impacts to amplify the net adverse impact. These include draw-downs of capital and surplus due to earthquakes or terrorist attacks and increased competition from self-insurance or other competing methods of risk-spreading.

Among the conclusions of a report commissioned to explore the relative roles of public and private insurance:

> *"Since the passage of the War Risk Insurance Act of 1914, Congress has developed one overriding principle to determine under what conditions the federal government should provide federal disaster insurance. ... Federal disaster insurance programs are permitted to correct a market failure in the private insurance sector. A market failure has been defined to exist when the private insurance industry is unable to provide primary insurance coverage at reasonable rates and/or does not have the capacity to provide reinsurance."*[27]

* For example, wind damages rise with the cube of the speed and can cause abrupt loss increases when gradual changes cross thresholds, e.g. when the point is reached that roofs disconnect from walls or when hailstone diameters/weights reach the level that they can break automobile windshields.

† Associated Press. 2005. "First-ever Seattle Heat Warning Issued." http://news.yahoo.com/news?tmpl=story&cid=533&e=6&u=/ap/20050528/ap_on_re_us/hot_seattle

‡ Exposures are still often expressed in terms of probable maximum losses for single events rather than for entire insurance seasons. The limitations of this approach were evident in 2004 U.S. hurricane season, with its $60 billion of economic losses (half of which were insured). However, it should be noted that lessons learned from Hurricane Andrew helped to manage these losses better than would otherwise have been the case.

The public must understand that insurers have no obligation to serve, and can only be expected to do so when the standards of insurability are met.

Governments and Individuals as "Insurers of Last Resort"

Governments assume a considerable share of the exposures to the costs of weather-related events. Requests for all forms of disaster relief (including those for the agriculture sector) and corresponding declarations doubled between the mid-1980s and mid-1990s (Figure 5-6), and total federal disaster-related payments amounted to $119 billion between 1993 and 1997 ($1993).[28] Within only one week of Hurricane Katrina, federal aid on the order of $40 billion was being discussed.

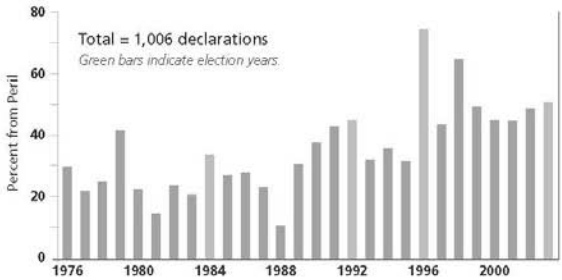

Figure 5. Impacts from Natural Disasters on the Government Sector are Also Diverse and Growing

Figure 6. Impacts from Natural Disasters on the Government Sector are Also Diverse and Growing

Surprisingly, **the U.S. government's full exposure has never been assessed.** It ranges from formal insurance programs (flood and multi-peril crop), to other forms of assistance such as disaster recovery and construction of flood defenses. As of mid-2004, the National Flood Insurance Program alone provided $723 billion in coverage for 4.5 million policyholders, up from about $50 billion in 1978. The program pays out over $1 billion in some years.*

The costs of natural disasters to government have also increased steadily in recent decades. Inflation-corrected federal relief payments for weather disasters grew 6-fold from the late 1960s to the early 1990s.[29] Of particular note, between the 1940s and the 1990s flood damages (insured and uninsured)—a major government-paid risk—grew 6-fold, to $6 billion per year (inflation corrected to $1997).[30]

The public sector has had mixed success in its role as a partner in understanding and managing weather-related risks. With the movement of FEMA into the Department of Homeland Security, observers have expressed concern that the shift of national focus to "manmade" disasters, as well as new layers of administration could inhibit FEMA's effectiveness.[31] Compounding the problem, more and more disaster preparedness and recovery has been pushed to the cash-strapped States.

State governments can also operate as insurers of last resort. One of the better known is Citizens Property Insurance Company in Florida. Citizens, which now covers 745,000 homeowners in the state via a fund available to those who cannot secure traditional insurance. Citizens experienced $2.5 billion in losses from the 2004 hurricanes. This, in turn, resulted in a 7 percent price increase to its customers, despite the fact that it charges premiums that are mandated to be higher than market rates. This increase took the form of a levy on private insurers in the state.[32]

Governments typically play a leadership role in disaster research. While the United States Government is a major sponsor of climate change research, the deficiency of economic impacts analysis and adequate models means that the results are rarely directly usable by the private sector. In contrast, this linkage is made relatively well in the case of earthquake modeling.

Governments cannot be expected to go it on their own. As an illustration of the importance of insurance, $40 billion of the total $66 billion cost of rebuilding New York after 9/11 flowed through the insurance sector,[33] with most of the balance managed by the federal government.

The U.S. Government Accountability Office (GAO) recently warned that insurers may increasingly look to government to share the economic risks of natural disasters.[34,35] **Yet, government is increasingly a reluctant partner.** With the country's shift of emphasis from natural disasters to terrorism, FEMA's role in disaster preparedness is being phased out.[36] In the end, the costs of climate change will increasingly fall on consumers and businesses. Important socioeconomic implications will arise depending on the extent to which the cost is spread through insurance, reinsurance, government taxation, or borne directly through formal or informal self insurance.† While insurance rate increases must be approved by insurance regulators, they, in many instances, lack the technical capacity to discharge this responsibility. For example, most state insurance regulatory offices don't have staff actuaries.

* See http://www.fema.gov/nfip/10110409.shtm

† There are a variety of alternative risk transfer approaches, which today are roughly equal in size to the traditional U.S. commercial insurance market. These include informal self insurance, Captives, Risk Retention Groups, Weather Derivatives, Catastrophe Bonds and other capital market schemes. Some entities also self insure but purchase reinsurance for catastrophe losses. For an overview, see http://www2.iii.org/media/hottopics/insurance/test3/.

Insurance Challenges Across the U.S.

In the remainder of this paper we examine the implications of climate change for the insurability of extreme weather-related events (large- as well as small-scale), and the consequences for affordability and availability of insurance. We offer separate discussions of the following insurance lines:

- Property (structures, industrial, auto, inland marine, aircraft)
- Crop
- Health/Life
- Business Interruption & Liability

We find that a wide range of insurance lines would be affected by extreme weather events under climate change. We project that insurance buyers will be expected to pay higher prices and deductibles, with lower limits on losses payable in many cases and that governments will be asked to assume an increasing share of exposures in some cases (Table 1). These conclusions are based on trends already underway in various US business/insurance sectors and the projected impacts as these trends play out further over the next 20 years, assuming middle-of-the-road climate change projections and current response strategies on the part of the insurance industry (i.e., responses similar to those seen in the face of past disasters). It is important to note that not all prospective impacts are negative. Several beneficial outcomes are noted in Table 1, although in balance the impacts are highly undesirable.

Among the key variables is how insurance regulators and governments respond to changing conditions (allowed rate increases, changes in terms, etc.). In some areas, the dual regulatory authority of federal and state governments converge, and can create potential points of conflict. While insurance regulation occurs primarily at the state level, disaster management is overseen at the federal level. For example, the federal flood program, and now terrorism backstop reinsurance, are handled from Washington. The difficulty in establishing and continuing the Terrorism Reinsurance Act evidences how difficult it can be to find a balance acceptable to insurers and governments alike.

Implications for Various Insurance Lines

There is no ideal way to segment the various hazards, perils, and lines of insurance. Most consequences of climate change affect more than one line of insurance. For example, extreme heat episodes have caused simultaneous insurance losses ranging from loss of life, to wildfire-driven property loss, to crop damages, to electric power plant shutdowns due to inadequate cooling water and associated business interruptions. In turn, wildfire losses touch many lines (Box 2). Similarly, a given customer class experiences many hazards, e.g., the energy sector experiences service disruptions from lightning strikes on the power grid to outages from lighting strikes or wildfires to property damages from hurricanes that damage underwater pipelines (Box 3). These types of linkages are reflected in Table 1. Here, we organize the discussion in terms of major insurance line. The treatment is indicative rather than comprehensive.

Property Insurance

Weather-sensitive segments of the property insurance market include homeowners, commercial lines, inland marine, as well as motor vehicle. Averages can be deceiving: the types of losses vary significantly from state to state (Figure 7) and from year to year. The costliest hailstorm* in Colorado history was $625 million ($1990).[37]

* U.S. property insurers pay out an average of $1.5 billion each year for hail-related claims, largely across the central U.S. (III 2000a).

Projected Changes during the 21st Century in Extreme Climate Phenomena	IPCC Assessment of Change Likelihood[a]	Representative Examples of Projected Impacts[b]	Peril or Hazard	Insurance-sector Impacts ("+" = increased losses "-" = reduced losses)							Insurance Customer Impacts		
				Property (structures; industrial)	Property (autos/marine/aircraft)	Liability: Business Interruption	Crop	Health	Life	Public Insurance/Assistance	Pricing	Exclusions	Availability
Higher maximum temperatures; more hot days and heat waves[d] over nearly all land areas	Very Likely	Increased hospitalizations over broad demographic range; incidence of death and serious illness in older age groups and urban poor	Heatwave					+	+	+			
		Increased heat stress in livestock and wildlife	Heatwave				+			+			
		Increased risk of damage to a number of crops	Heatwave				+			+			
		Increased soil subsidence	Subsidence	+		+				+			
		Decreased ice in northern maritime shipping lanes	Float ice		-								
		Increased roadway accidents (slower reaction time)	Road conditions		+								
		Increased electric cooling demand and reduced energy supply reliability	Power Outage			+				+			
Higher (increasing) minimum temperatures; fewer cold days, frost days, and cold wavesdover nearly all land areas	Very Likely	Decreased cold-related human morbidity and mortality	Coldwave					-	-	-			
		Decreased risk of damage to a number of crops, and increased risk to others	Heatwave				-			-			
		Extended range, reproduction, and activity of some pest (e.g. pine beetle) and disease vectors	Infestation	+		+	+	+	+	+			
		Increased avalanche risk	Avalanche	+		+							
		Increased permafrost melt	Subsidence	+		+				+			
		Increased incidence of lightning	Lightning	+	+	+	+			+			
More intense precipitation events (Very Likely[a] over many areas)	Very Likely, over many areas	Increased flood, landslide, avalanche, and mudslide damage	Flood, landsclide, avalanche, mudslide	+	+	+				+			
		Increased soil erosion; mudslides	Rain							+			
		Increased flood runoff could increase recharge of some floodplain aquifers	Flood				-			-			
		Increased roadway accidents (driving conditions, visibility)	Road conditions		+			+	+				
Increased summer drying over most mid-latitude continental interiors and associated risk of drought	Likely	Decreased crop yields	Drought				+			+			
		Increased damage to building foundations caused by ground shrinkage	Subsidence	+									
		Decreased water resource quantity and quality	Drought			+	+	+		+			
		Increased risk of wildfire	Wildfire	+	+	+	+	+	+	+			
Increase in tropical cyclone peak wind intensities, mean and peak precipitation intensities[e]	Likely	Increased risks of property damage, business interruption, loss of human life, infectious disease epidemics	Wind, disease	+	+	+	+	+	+	+			
		Increased coastal erosion and damage to coastal buildings and infrastructure [tidal surge insured under NFIP]	Tidal surge							+			
		Increased damage to coastal ecosystems such as coral reefs and mangroves	Tidal surge	+	+	+	+	+	+	+			
Intensified droughts and floods associated with El Niño events in many different regions	Likely	Decreased agricultural and rangeland productivity in drought- and flood-prone regions	Drought				+			+			
		Decreased hydro-power potential in drought-prone regions	Drought			+				+			
Increased intensity of mid-latitude storms[d]	Little agreement between current models as of 2001. Subsequent research (Knutson/Trenberth/MIT/ABI) has shown increased likelihood of hurricane damages	Increased risks to human life and health	Storm					+	+	+			
		Increased property and infrastructure losses	Storm	+	+	+	+			+			
		Increased damage to coastal ecosystems, including loss of mangroves and coastal wetlands	Storm	+	+	+				+			

a Likelihood refers to judgmental estimates of confidence used by Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report (TAR), Working Group I: very likely (90-99% chance); likely (66-90% chance). Unless otherwise stated, information on climate phenomena is taken from the IPCC Summary for Policymakers, TAR WGI.
b These impacts can be lessened by appropriate response measures.
c Based on information from chapters in the IPCC Third Assessment Report; high confidence refers to probabilities between 67 and 95% as described in Footnote 6 of TAR WGII, Summary for Policymakers.
d Information from IPCC Third Assessment Report, Working Group I, Technical Summary, Section F.5.
e Changes in regional distribution of tropical cyclones are possible but have not been established.

Table 1. Examples of Impacts Resulting from Projected Changes in Extreme Climate Events, and associated insurance implications. (Adapted from IPCC/Vellinga et al., 2001)

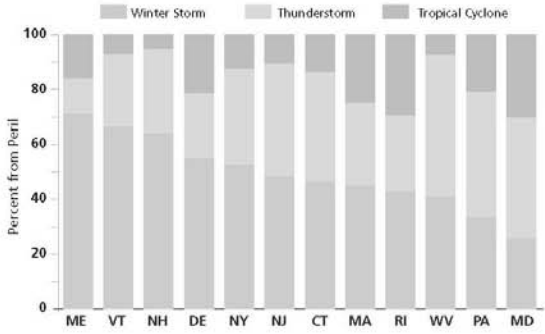

Figure 7. Percentage contribution of winter storms, thunderstorms, and tropical cyclones to total weather-related losses in the Northeastern U.S.: 1980–2004. (Source: AmRe 2005)

Windstorms: The greatest near-term insurability challenge will probably concern windstorm losses. In a real-world example, Allstate stopped writing commercial insurance policies in Florida and decided not to renew 95,000 residential homeowner policies (about 15 percent of its portfolio there), because of the four hurricanes that slammed Florida in 2004.[38]

Windstorm is a major concern, and the largest single contributor to weather-related insurance losses in the U.S. The effects of climate change on hurricanes are extremely difficult to assess. Recent literature has pointed to more of a linkage than previously believed.[39,40] A new study from MIT reviewed 50 years of data and found that over that time both the duration and wind speed of hurricanes has increased 50 percent.[41] It also identified a "high correlation" between this increase in intensity and the rise of surface water temperatures.

The insurance industry and others have made material progress toward improving the resilience to hurricanes, including fortified building codes (and code compliance), the development of catastrophe modeling, and consumer education. Yet, vulnerabilities remain and the Insurance Information Institute notes "serious obstacles to reducing CAT losses" (III 2002). These include unwillingness to significantly alter land use planning, political/lobbying efforts of special interests to defeat restrictions, homeowner opposition to added housing costs for disaster resilience, and subsidies (flood insurance, rate suppression), coupled with demographic trends (housing starts, population, rising replacement values).

Thunderstorms and Winterstorms: The cumulative annual insured losses from U.S. thunderstorms have averaged $3 billion per year since 1980 ($2004), equating to those from a large hurricane in most years. One confounding factor in tracking thunderstorm losses is that some events are associated with hurricanes, and counted in that category. Thunderstorm losses have shown a significant increase over the past 25 years, even after correcting for inflation (Figure 8). The worst year in recent history (2003) saw nearly $8 billion in insured losses.

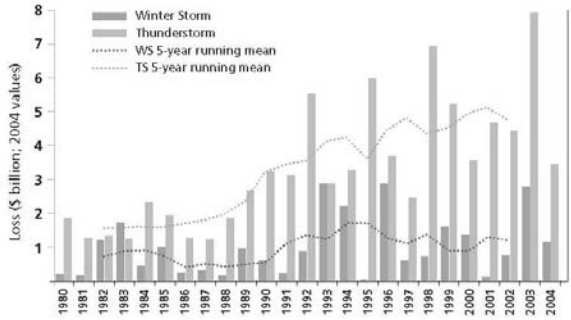

Figure 8. Thunderstorms on the rise: 1980–2004. Annual insured losses due to thunderstorm and winter storm events. The five-year running mean is also shown. Source: AmRe (2005)

Winter storms are a significant contributor to weather-related losses in New England, the Pacific Northwest and the Rocky Mountain states, accounting for about 18% of insured catastrophe losses nationally, and ranging up to 60% in Maine, New Hampshire and Vermont. They present a variety of hazards, including wind, tornado, snow, sleet, ice, hail, and freezing rain, sub-freezing temperatures, and lightning, varying from storm to storm and region to region.* Damages are similarly diverse, including frozen pipes and consequent water damage, ice-damming and roof damages, and increased vehicle accidents. Winter storms in the United States often fall below the threshold of being cataloged among official loss statistics, yet, cumulatively yield more than $1 billion each year in insured losses.† For example, only one winter storm event in 2004 met Munich Re's criteria to be classified as a significant event, incurring economic losses in excess of $1 billion. The most costly winter storm in recent history was a $2.3 billion event ($2004) in 1993.

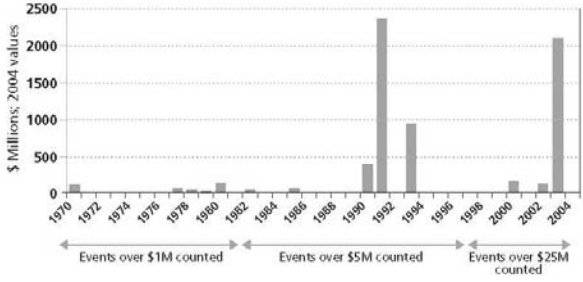

Figure 9. Rising U.S. Catastrophic Insurance Losses, despite fewer fires included in the sample. Source: Insurance Information Institute.

Wildfire: Wildfire is another major weather-related hazard, and one that will be exacerbated by the combination of climate change, population growth, and development

* The Ice Storm of 1998 resulted in the largest catastrophe that produced the largest loss in Canadian history, and combined Canadian and US stood in excess of $1.2B US.

† These events can be defined as any extra-tropical cyclone that incurs a majority of the insured losses associated with it through the effects of frozen precipitation, high winds associated with the storm's circulation, and/or excessively low temperatures from one or more preceding or subsequent high-pressure systems

in at-risk areas. Wildfires have over the years plagued areas of the United States from New Hampshire and Vermont, to Colorado, to California. From 1985 through 1994 U.S. wildfires claimed more than 9,000 homes[42] at an average insured cost of nearly an order of magnitude greater than during the three decades prior to 1985. According to the Insurance Information Institute, the total US losses from catastrophic wildfires (a small subset of the total defined in terms of events tabulated by the Property Claims Services) was $6.5 billion ($2004) between 1970 and 2004, corresponding to an average insured loss of just over $400 million per fire (Figure 9), with damages rising from about 40 acres per fire in the 1970s to 80 acres per fire in recent years (Figure 10).

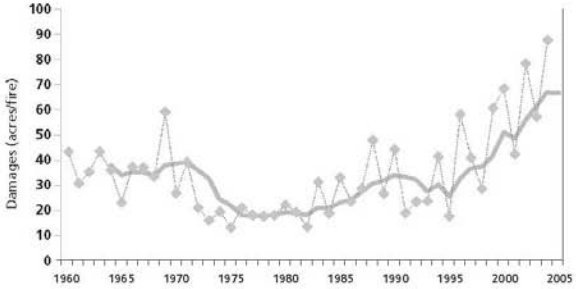

Figure 10. U.S. Wildfire Intensity has Doubled Since 1960. Source: National Interagency Fire Center

Wildfires can be costly disasters for property owners, governments (federal, state and municipal), and insurers. Two fires in California in 2003 caused combined insured losses of $2.1 billion,[43] comparable to those from the Oakland Hills fire of 1991. These conflagrations include "forest fires, prairie fires and brush fires". According to the U. S. Department of Agriculture, "nearly every state has experienced wildland/urban interface fire losses."[44]

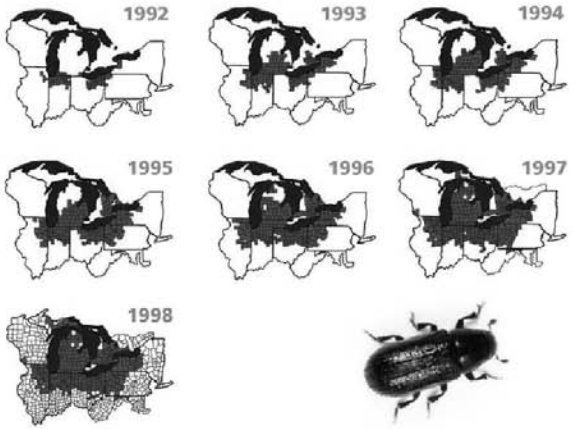

Figure 11. Temperature-Induced Spreading Pine Beetle Causes Elevated Wildfire Risk. The Pine Shoot beetle, an exotic species, is now found in twelve northern states: Illinois, Indiana, Maine, Maryland, Michigan, New Hampshire, New York, Ohio, Pennsylvania, Vermont, West Virginia and Wisconsin. Beetle birth rates and geographical range increase with temperature.

Weather-related drivers include temperatures, humidity, wind, fuel-moisture content, and fuel types. Drought weakens trees and in many cases conspires with higher temperatures to foster super-infestations of forest pests (Figure 11), such as pine and spruce beetles (which cause nearly 50-times the economic damage of wildfires[45]), with significantly elevated wildfire risk. Outbreaks in parts of Alaska—causally correlated with unusually high temperatures—have killed 90 percent of the spruce.[46] Lightning, also a weather-related phenomenon, is a major source of wildfire ignitions (Box 4). As forests and shrubs are the primary terrestrial carbon sink, the fires and losses add substantially to the atmospheric accumulation of carbon dioxide. **An analysis that included only the effects of temperature and wind, projected that wildfire damages in California would quadruple—even with today's full suppression resources brought to bear**—in some parts of the state under climate change.[47]

Coastal Erosion: Coastal erosion is a hazard that is not insured by the public or private sectors in the U.S. However, the federal flood program will pay for coastal erosion damage when there has been insured flood damage from a storm.[48] **Under climate change, government-insured flood losses will increase due to the combination of sea-level rise, increased storm surges, and potentially stronger storms** (Figure 12). This will be a future problem for both the National Flood Insurance Program and the increasing number of coastal property owners.

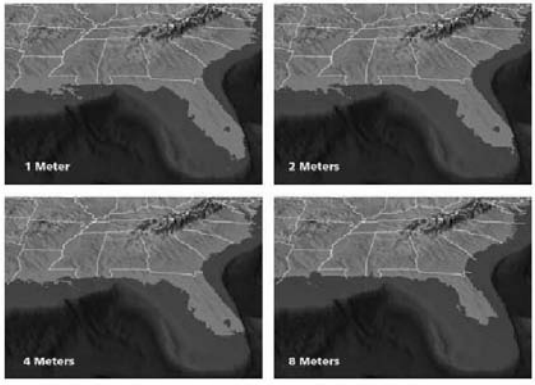

Figure 12. Coastal Inundation Arising from Hypothetical Increases in Sea Level.
Source: GFDL/NOAA

Water-related damage. This widely recognized crisis in several property insurance markets today* is linked to a number of weather-related factors, each of which is expected to become more severe under climate change. Small-scale events are as or more significant than major catastrophes. This is reflected by a growing number of lawsuits that target builders, contractors, developers, sub-contractors, material suppliers, product manufacturers, and architects & engineers. The subject of these suits often center on construction defects claims arising from:

- Subsidence, collapse, cracks in walls and foundations.
- Leaking roofs, windows, doors, and foundations.
- Dry rot of wood or other building materials, pest infestations.
- Mold, code violations, improper specification of building materials.

* Hotspots include California, Nevada, Colorado, Texas, the Carolinas, Florida, and New York.

Personal automobile insurance and cover for other types of transport systems, including aviation: This sector is more weather sensitive than some realize. Windstorms, hail, flooding and earthquakes give rise to a surprisingly high number of automobile claims under the physical damage coverage, as PCS reports. This is due to direct damage (hail or flood) or flying objects (windstorm and earthquake). Up to 50 percent of the insured losses from catastrophes recorded by PCS were due to automobile damages (Figure 13). Vehicle accidents also increase during various forms of adverse weather, ranging from rainy conditions to heatwaves. During the 1994 Northridge earthquake, there were 37,000 reported damage claims to automobiles from crushing or falling objects, although the average claim was about $1,500 (representing less than 1 percent of the total dollar damage from that event, which was about $15 billion). The salient point here is that under either property or liability coverages, unexpected types of claims from natural events already do occur and can be expected to occur in the future. Similarly, aviation losses are also significant, particularly from hail storms.

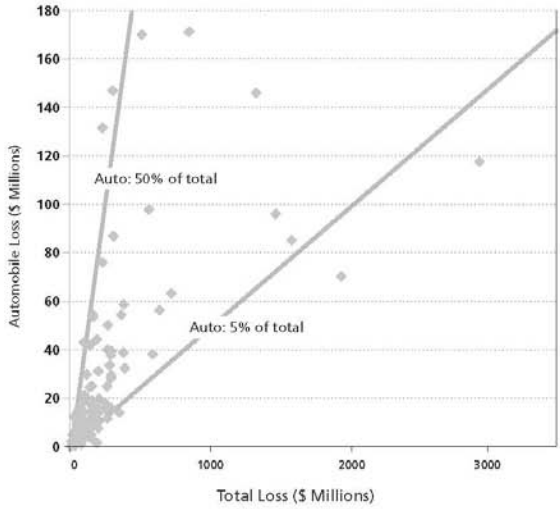

Figure 13. Significant Automobile Damage Losses Arise from U.S. Catastrophes (1/1996–9/2000). Automobile losses can exceed 50% of total catastrophe losses. In the U.S., 16% of automobile accidents are attributed to adverse weather conditions as are one-third of the accidents in Canada. Autos also sustain insurance losses during natural disasters, amounting to $3.4 billion and 1.7 million claims between 1/1996 and 9/2000 (PCS 2000) and averaging 10% of total disaster related property losses, with much greater losses for some events, particularly hailstorm. Individual events have seen as much as 55% of total losses attributed to autos. These data systematically underestimate total losses because PCS records include only those events with total losses of $25M or more. Source: ISO/Property Claims Services.

Crop Insurance

Agriculture is well known as a climate- and weather-sensitive sector. Hazards include drought, excessive rain, flood, hail, heatwaves, windstorm, wildfire, insect infestation, and plant diseases. Drought is one of the most pervasive hazards, as illustrated by the $8.3 billion total economic losses in the U.S. in 2002.[49] Climate change impacts also include more vigorous weed growth (as a result of the well-known "fertilization" effect of increased CO2 concentrations in the atmosphere). Heatwaves in Europe in 2003 caused $12 billion in crop losses, which could be a harbinger of things to come in the U.S. As shown in Figure 14, insured U.S. crop-hail losses climbed steadily from $40 million in 1948 to nearly $400 million in the

early-to mid 1990s.[50]

Flood is also an important hazard for agriculture. The 1993 US Midwest floods resulted in losses of $6–8 billion (about half of the total), although most due to excess soil moisture from rain as opposed to direct crop loss.[51]

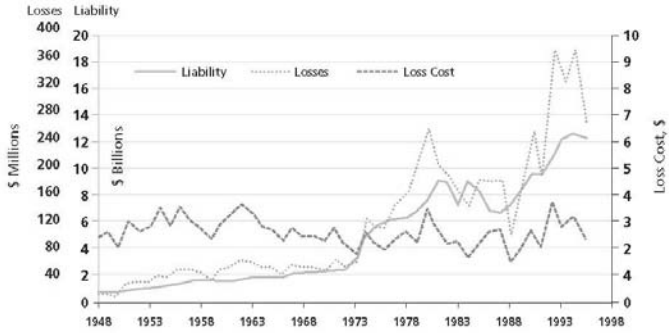

Figure 14. Annual Losses under U.S. Crop-hail Insurance in the United States: 1948–1995. Source: Changnon (1997)

While some models predict increased crop yields under climate change due to more precipitation, this has been shown to be a flawed analysis where rainfall is expected to be uniform, rather than the more likely outcome of being concentrated in torrential downpours, which creates soil moisture saturation and loss of topsoil, both of which are very damaging to crops. **U.S. corn losses in the U.S. due to soil moisture saturation alone are expected to double to $3 billion/year over the next three decades.**[52]

Private crop-hail insurance represents a market of about $500 million/year in premiums and is generally profitable nationally, but losses in certain regions already significantly exceed premiums (e.g. in 2003 payouts exceeded payments by a factor of 2.4:1 in West Virginia and 1.4:1 in Kentucky) (III 2005). Public multi-peril (or "all-risk") crop insurance represented a market of about $2 billion in premiums in 2003, with a payout/premium ratio of 1.24:1. Over 200 products are insured, and those that are not are covered under the federal Noninsured Crop Disaster Assistance Program. Since payouts are generally yield-related, farmers needn't experience a complete or catastrophic loss to make a claim.

Governments assume crop risks because private insurance firms find them too unpredictable and too undiversified to insure at prices that the market could bear. The Great Drought and ensuing "dust bowl" of the 1930s triggered the establishment of a "multi-peril" federal crop insurance program* in the U.S. to cover other hazards, including drought. Private insurers retained the crop-hail segment of the market (which also includes fire), and in 1980 were asked to administer the public program and share some of the risk with the federal government as well. By 2004, over 220 million acres of cropland were insured. The federal government pays a portion of the premium for multi-peril and revenue-loss insurance (to cover administrative and claims-handling costs) and reinsures a portion of the losses. The government pays entire premium for catastrophic losses. The government serves as "insurer of last resort" if the private insurers fail to pay their intended share of claims. Those with insurance retain the costs associated with deductibles and caps on coverage.

Until "loopholes" were closed around 1985, only about a third of farmers purchased multi-peril crop insurance, the remainder relying on (free) disaster relief and emergency loans,

* The Federal Crop Insurance Act of 1938.

which averaged $1.5 billion/year between 1988 and 1994. Livestock insurance is currently available in 19 states, and covers milk production in 12 states.[53]

Crop insurers have recognized the risks posed by climate change.[54] Many of the risks are perceived as uninsurable. Crop insurance systems are already under stress. **Crop insurance losses have grown 10-fold in recent decades**, and in some years the government's crop and flood insurance programs have been unprofitable.[55, 56] Any increase in the frequency of loss events will further tax insurance systems by drawing down capital and surplus at a rate differentially faster than they can be replenished, thus increasing the need for subsidies.

Weather-related events have already been observed to upset the financial stability of crop insurers. As a result of drought and poor fiscal management, the largest private participant (American Growers Insurance Company) became insolvent* after having operated successfully for 56 years. This event showed the weather sensitivity of the sector and risks to insurers and prompted considerable concern by the government. The US Government Accountability Office issued a report[57] finding that the federal agency designated to oversee the financial health of the crop insurance program needed to implement better methods to monitor and communicate with participating insurers and their regulators. The transition cost the government $40 million. Nationally, the drought caused an increase in losses of approximately 33 percent ($1 billion) to the federal crop program (USGAO 2004). In 2002, $139 was paid in claims for every $100 collected in premiums (III 2005). Climate change is projected to cause extensive drying in most of the United States (Fig. 15), with adverse effects on crops.

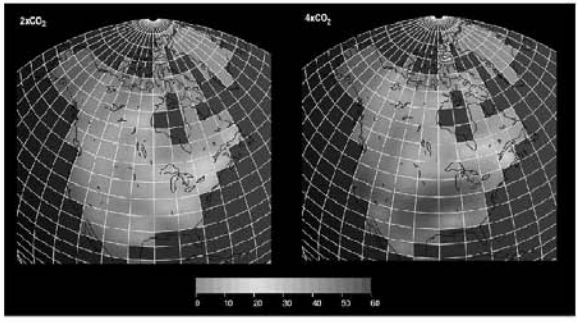

Figure 15. Potential Effect of Global Warming on Soil Moisture in North America. Drying underlies consequences for agriculture (moisture, pests, and diseases), forests, water supply, property (via subsidence), respiratory health (via airborne particulates), etc. Source: NOAA/GFDL.

Health/Life Insurance

The life/health segment represents a large share of US insurance premium volumes. Climate change is expected to adversely impact the prevalence of vector-borne diseases, heat stress, water quality, aeroallergens (such as pollens† and mold), and the health of non-human systems that can cause economic and insured losses for humans (e.g. forest beetle infestations leading to wildfires which increase airborn particulate pollution). Natural disasters also have material impacts on mental health. An in-depth treatment of the issue will be provided in the forthcoming "Climate Change Futures" study, conducted by the Harvard Medical School's Center for Health and the Global Environment and sponsored by Swiss Re and the UN Development Programme.

* Technically, the Nebraska Department of Insurance took control of the company in an effort to address the fiscal problems.

† Pollen has been observed to increase by 60% with a doubling of pre-industrial atmospheric CO_2 concentrations.

The combination of **more airborne allergens, rising temperatures, greater humidity, more wildfires*, and more dust and particulates may considerably exacerbate upper respiratory disease (rhinitis [hay fever], conjunctivitis, sinusitis) and cardiovascular disease** (e.g., due to reduced oxygen and increased carbon monoxide during fires). Cases of asthma, which are already causing greater impacts than Alzheimers disease, would sharply increase. The baseline cost for asthma was $13B/year in the U.S. alone as of the mid-1990s (half of which are direct healthcare costs). If a 30 percent increase took place in the U.S., the incremental cost of $4 billion/year would be on a par with that of a very large hurricane.

Short of a major epidemic, life insurance losses are not likely to increase significantly in the U.S. However, losses would rise from current levels and could be quite significant in emerging markets (where U.S. insurers increasingly seek to do business).

Business Interruption and Liability Insurance

Business interruption and liability claims due to climate change are probably the least well understood class of exposures. They take several forms. Business-interruption coverage is neither a liability nor a property coverage. It is a separate coverage insuring the lost profits and expenses due to down time and the costs of locating in a temporary facility.

Business-interruption: Losses due to the disruption of business operations typically range from 20 to 40 percent of claims resulting from hurricanes. Other weather-related triggers for business-interruption claims include lightning, flood, and wildfire. Visibility problems during wildfires in Malaysia this summer forced the closing of the country's largest port and many businesses.[58] Hurricane losses are not limited to property damages. For example, $0.5 billion insured crop losses resulted from hurricanes in 2004 (III 2005).

During natural catastrophes, it is generally unusual for a claim to arise under liability insurance, since there must be a negligent act that causes damage to another's property. It could happen when a landslide on the property damages a neighbor's property, or by not being attentive to poor road conditions in driving, as mentioned. Government entities are often sued after landslides. Contractors' liability and mold problems have been liability issues in California, but legal developments and policy changes will make these claims more difficult in the future.

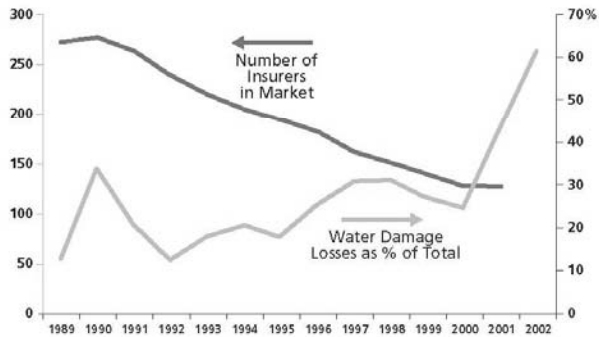

Figure 16. Texas Insurers Leave Market as Water-Damage Claims Rise. Source: Insurance Information Institute, Hartwig (2003).

* According to the study, hospital admissions for heart and lung ailments increased significantly at the height of the wildfire season, most notably in Ravalli County. Admissions for respiratory disease went from 8.6 per 10,000 residents in 1999 to 16.4 per 10,000 during the 2000 wildfire season — a 90% increase. Admissions for heart problems went from 22.1 per 10,000 residents to 34.6 — a 57% increase.

Liability: Claims are already significant from property damages due to mold and moisture (product liability, professional liability). This issue has become a crisis for insurers in some regions, as evidenced by 37,000 claims in Texas alone in 2001, with claims of $3 billion the following year (Figure 16).[59] While the upsurge in claims was partly due to excessive litigation and media exaggeration, there was also an underlying fact of increased moisture-related losses (up more than four-fold in Texas compared to the prior decade, representing 60 percent of homeowners' claims value) and changes in construction practices that fostered mold production.* Data from the Insurance Information Institute† indicates that:

- Water-related claims 60 percent of total in Texas, 30 percent in California
- All but 19 states had mold exclusions as of 2002
- Cost $444/household (premium increase) in Texas.[60]
- $850 million in paid claims in 2001 (equal to a significant hurricane); $35,000/claim
- The issue is "migrating" to commercial lines (property, liability, workers comp, commercial liability, and business interruption).
- **Insurers say that mold will threaten affordability, and are clearly leaving the Texas market** (Figure 17)

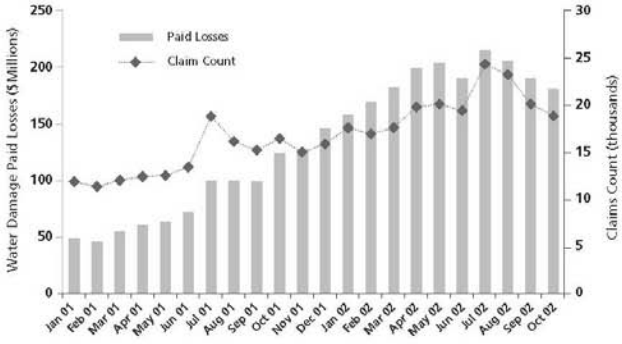

Figure 17. Annual Water Claim Costs on a Par with Those from A Large Hurricane.
Source: Insurance Information Institute, Hartwig (2003).

Corporate liabilities may eventually arise from claims against large emitters of greenhouse gases.[61] This is being played out first in the US, as is evidenced by Attorneys General from NY, CA, CT, ME, NJ, RI, VT filing lawsuits against five electric power companies to force reductions of GHG emissions over 10 years. Numerous state treasurers have also called for corporate disclosure of financial risks of global warming.

Directors and Officers (D&O) liability has already been identified as an arena in which climate-change impacts may be brought back to insurers. In the post-Enron, post-WorldCom marketplace, there is considerable concern about the ability of corporate leadership to proactively manage risks and anticipate business threats. Reinsurer Swiss Re is concerned that D&O policyholders do not understand that climate change risks may influence the financial performance or even solvency of their companies, and has asked policyholders to present their plans for mitigating risk.

* A popular misconception is that energy efficiency is the cause of the mold/moisture problem (e.g. see Prahl (undated)). While bad application of energy efficiency features can cause such problems, the root cause is bad construction practice (efficient or otherwise).

† Information posted here http://www.iii.org/media/hottopics/insurance/mold2/, and in presentations on the site by Robert Hartwig.

Pressure on Insurance Affordability & Availability under Climate Change

Extreme weather events have already precipitated contraction of insurance coverage in some markets, and the process can be expected to continue if the losses from such events increase in the future. Impacts vary, of course, depending on the specific circumstances, and can be relatively minor (gradual price increases) to more significant. While not a weather-related event, the Northridge Earthquake of 1994 provides a sobering example of how trend changes in natural disasters can lead to serious questions of insurability and undesirable outcomes for consumers (Box 5).

While regulation is a key factor in the evolution of these changes, it must also be kept in mind that various forms of insurance (e.g., surplus lines and "country municipals") have limited regulation. Most domestic reinsurers are fully licensed and regulated insurers. (Foreign reinsurers must maintain deposits in the United States in order for the primary insurer to take credit for the reinsurance on its balance sheet.) It is also worth noting that insurance also comes under the purview of non-insurance regulatory bodies, e.g., the SEC for corporate governance and independent rating agencies, such as Standard & Poor's and A.M. Best & Co., and some industry observers say that the time may be coming where these groups have more influence than traditional insurance regulators.[62]

Based on the preceding insurance-line assessments, we offer the following outlook for the types of issues discussed in this paper:

- **Flood** - currently a mix of public/private insurance and risk sharing. Under climate change, we expect insurability problems to extend from the present personal and small-commercial lines into larger commercial lines. To highlight this issue, one need only look to the enormous flood losses of Hurricane Katrina.
- **Windstorm—**a largely insured risk at present. We are already seeing considerable insurability problems and associated changes in terms and pricing, non-renewals, market withdrawl, etc. This could increase dramatically under climate change, resulting in shifting of losses to governments and consumers.
- **Agriculture and livestock**—currently a public/private insurance partnership. Climate change will stress this sector considerably, with potential for impacts due to drought, flood, pests, or other events on a scale with the Great Dust Bowl of the 1930s. The public crop program could become insolvent, although it would likely continue provide coverage for political and socioeconomic (public policy) reasons.
- **Wildfire**—currently largely privately insured. We anticipate an evolution similar to that seen from the earthquake hazard, i.e., more retention of risk by purchasers of insurance and more involvement by state governments, while insurers raise deductibles and reduce limits of liability and scope of coverage.
- **Mold and moisture damage**—largely commercially insured until the crisis emerged a few years ago. Now, many states have exclusions. A Federal Mold Pool has been proposed as House Bill 5040 and endorsed by some stakeholders,[63] which would shift this risk to the government sector.
- **Earth movement and coastal erosion**—primarily insured by government, if at all. With permafrost melt, subsidence of dry soils, sinkholes will become more prevalent, as will mudslides and property losses from coastal erosion. Government programs covering storm-surge-driven losses on eroded property could be overwhelmed with losses under climate change, with the result of more retention by property owners.
- **Health impacts**—currently largely privately insured. We do not anticipate an insurability crisis under climate change. Certain forms of losses could increase sharply, however, particularly concerning respiratory disease. Impacts will manifest in the form of elevated health insurance prices. The U.S. government has assumed a steadily increasing share of health insurance costs, up from about 25 percent in 1965 to almost 50 percent today.[64]

The aggregate effect of these findings is towards rising insurability problems resulting in structural changes that will alter the current risk-spreading formula in the United States. An example of this has been evidenced (according to the Insurance Information Institute) in hail-prone parts of Texas, Kansas, Kentucky, and other mid-western states where, in addition to tightening deductibles, some companies are providing coverage for roofs on a depreciated (actual cash value), rather than a replacement-cost basis.

Governments already play a role in preparing for or recovering from virtually every type of climate-related loss we have examined, and will be called upon to do more. Consumers and businesses will be required to assume a larger proportion of a growing absolute level of losses, both via deductibles that precede paid loss as well as via costs that exceed coverage limits [essentially as "self (re)insurers"], either directly or as taxpayers who receive government assistance in the aftermath of extreme weather events. As seen with the existing flood program, governments have historically set relatively low limits on losses ($250,000 for personal lines and $500,000 for commercial lines), and exclude coverage for temporary living expenses or business interruptions.

Insurers can be largely insulated from these impacts, as long as regulators award an adequate combination of rate increases and permission to change terms and market participation. This could translate into some slowing of growth in commercial insurance premium volumes, but also lower claims.

Proactive Measures

There exist a host of solutions that are desirable for the business community and consumers alike. They require, however, successfully overcoming and integrating responses to a combination of technical and policy related hurdles. Thus, there must be a willingness to seek solutions and to build the structure for policy implementation, as well as good actuarial analysis and catastrophe modeling.

Success will depend on emphasizing science rather than rhetoric (at either end of the political and ideological spectrum), and fostering understanding rather than polarization. This can have a counterproductive effect on sound risk analysis and management. **Proof of climate change claims and counter-claims by "vigorous assertion" and research based on preconceived outcomes, makes for dramatic news headlines but fails to genuinely address the nonpolitical and hopefully multi-partisan desire to safeguard homeowners and businesses from the fallout of natural disasters.**

Logical participants include four key stakeholder groups: Insurers, their regulators, the governments at all levels, and consumers. Following are some thoughts on the roles these groups can play while working in unison. Public-private partnerships are clearly essential. Insurers and governments have devised and must continue to craft innovative means spreading financial risk while fostering loss-prevention practices.[65, 66]

Insurers

- **Strive to improve loss data collection and actuarial analysis.** Better (more thorough) data collection and analysis of observed trends (attribution analysis—what is the role of climate change versus socioeconomic/demographic drivers?)
- **Strive to increase use of risk management.** For example, when indoor air quality issues first arose, insurers, fearing catastrophic and un-manageable losses, excluded coverage.[67] As the years passed, insurers have learned more about building science and ways to pre-empt problems through better building design and operation, with the result that the situation has begun to shift from "problem" to "opportunity".[68]
- **Encourage policy action and technical measures to achieve greenhouse greenhouse-gas emissions reductions, especially where there are collateral benefits to the insurance core business.**[69] For example, FM Global promoted energy-efficient "torchiere" light fixtures because of their fire-safety benefits.[70] An aggressive energy efficiency campaign in

California avoided 50 to 150 hours of rolling blackouts during the summer of 2001.[71] Most energy efficiency strategies also provide peak-demand reductions, which are beneficial in the event of power shortages e.g., during extreme temperature events. The American Insurance Association has endorsed various forms of emissions-reduction strategies (as well as land-use planning), observing that some have the "win-win" benefit of reduced insurance hazards (Box 6). They also, rightfully, point out that care should be taken to ensure that climate-change mitigation strategies do not have inadvertent adverse consequences on the insurance core business.

- **Engage in weather/climate science and promote the use of scientific knowledge and climate modeling.** While insurers should not be expected to conduct basic research, their deep understanding of risk assessment and management, coupled with their traditions of data collection, represent potent ways in which they could augment existing climate science work. One of the potential outcomes—better modeling— could significantly improve the quality and applicability of data and risk analyses, facilitating availability of insurance in regions where the current lack of information is an obstacle to market development (Box 7). This potential is exemplified by a possible shift in the industry towards accepting flood risks where they previously had been viewed as uninsurable. This would constitute a major change in the perspective of insurers regarding this particular hazard (Swiss Re 2002). CAT modelers also recognize the need for this.[72] A very positive precedent for this type of work has been set in the case of earthquake insurance.
- **Reconstitute something along the lines of the climate change insurance working group that was active in the mid-1990s.*** While the exact membership could certainly be expanded, there would be real benefit of new dialogue among trade associations, their member companies, and unaffiliated insurers.

Insurance Regulators

- **Review the "standards of insurability" to identify new challenges, domestically and abroad.** Given the changing conditions, it would be prudent for regulators to revisit the standards of insurability and examine the various climate-related hazards (on a line-by-line basis) in this context. The potential for insurer-initiated risk management should be evaluated for risks that are deemed currently or potentially uninsurable. As U.S. insurers do more business overseas, the risks there must be assessed as well.
- **Incorporate climate risks in solvency and consumer-impact analysis.** In anticipation of a continued rise in losses (faster than premiums), regulators will need to redouble their efforts to ensure solvency and to encourage best practices among insurers which will, in turn, minimize adverse consumer impacts. An important example was the All-Industry Research Advisory Council's report in 1986, which surprised the insurance community by quantifying the considerable effect of multiple mega-catastrophes on insurer solvency.[73] It is remarkable that this work has not been replicated or updated over the intervening 20 years. One area that merits analysis is the degree to which insurer investments may unexpectedly decline in value if they have not been thoroughly vetted for climate risk issue.
- **Encourage insurers to collect more comprehensive data on weather-related losses.** Currently there is scant information on the role of weather events in vehicle accidents, power outages, and, especially, health-related losses. While catastrophe losses are relatively well documented, few comprehensive statistics exist for equally important "small-scale" events such as lightning strikes and soil subsidence. The existing floor of $25 million per loss erodes the value of the PCS data.† Relaxing this limit within PCS, or

* The original members are listed in the Key Findings section.

† According to the Insurance Information Institute, when the floor was raised from $5M in 1996 to $25M in 1997, the number of catastrophes fell from 41 in 1996 to 25 in 1997, mostly due to this reclassification. See http://www.iii.org/media/hottopics/insurance/xxx/

creating a new data-gathering body would be of value. Basic insurance loss data should be available in the public domain.

- **Elevate the standards for catastrophe modeling.** In order to assess exposures of insurers and their customers, CAT models (or other tools) must integrate the processes climate change. The models should be subject to peer review. The Florida Commission on Hurricane Loss Projection Methodology may be a good model for replication.* Existing CAT models, however, only cover a subset of insurance-relevant climate change impacts. These voids should be filled with new modeling methods.
- **Assess exposures of insurer investments and adequacy of capital and surplus to weather extremes.** Extreme weather events will affect the financial markets, real estate, and other assets in which insurer capital and surplus are invested.† Analyses of the potential for erosion of capital and surplus or liquidity problems should include potential shifts in weather impacts, and insurers themselves must make this assessment, the result of which will be confidential and held by the insurer but accessible to regulators. While the $300+ billion insurer surplus is often cited as adequate for disasters, only a fraction of it is available to any particular category of loss.
- **Explore the feasibility of developing a catastrophe exposure questionnaire similar the California Insurance Department's annual Earthquake Questionnaire.** Doing so for climate change would be more complicated, and certainly would have to be implemented at the level of specific perils (e.g., hurricanes).

Governments

- **Foster and participate in public-private partnerships for risk spreading.** If executed properly, potent synergisms can help maintain insurability where coverage could otherwise be withdrawn. Various levels (from local to international) can contribute here. The following three bullets exemplify the opportunities.
- **Enhance adaptive capacity through planning and disaster response.** Governments can help maintain (or even restore) insurability via improved land use planning, building codes, early warning systems, and disaster recovery. Hurricane Katrina highlights the need for and pre-event loss assessments in-depth planning and a higher level of preparedness.
- **Take policy action to reduce greenhouse-gas emissions.** Governments are already engaged in efforts to reduce greenhouse-gas emissions, and these efforts should be redoubled.
- **Reduce vulnerability to disaster losses.** The American Insurance Association (AIA 2000) offered six recommendations to the OECD for mitigating catastrophe risk. These included early warning systems, better land-use planning, improved building codes and catastrophe-resistant reconstruction, improved coordination and planning of national and international relief efforts, assistance in catastrophe contingency planning, and support for pre- and post-event mitigation and response. Local governments often have lead responsibility for the above-mentioned activities.
- **Promote basic research on climate change and loss modeling, and issue climate change hazard maps.** By analogy, the hazard maps for earthquake indicate risks of liquefaction, landslides that could result from earthquakes. In the case of climate change, such maps could show the relevant projected impacts, by peril. Po licymakers must reckon with the fact that budget constraints have in the past impeded the implementation and updating of hazard maps.
- **comprehensively assess the government's overall financial exposure to weather disasters.** Including impacts on flood and crop insurance, emergency disaster relief and as significant owners of weather-sensitive infrastructure.

* See http://www.sbafla.com/methodology/

† According to Hartwig (2002), insurers held over $3 trillion in stocks and bonds alone, as of the year 2001.

Consumers

- **Minimize disaster losses through the use of recognized pre-loss mitigation practices.** Consumers (whether in households or business sector) must ultimately understand and weigh the risks they face, adopt loss-prevention measures, and make informed insurance purchasing decisions.
- **Curb emissions that cause climate change, primarily by enhancing energy efficiency and increasing the use of carbon-free energy sources.** Ultimately, it is insurance consumers (whether homeowners, renters, businesses, and industries) that consume energy and contribute to other causes of climate change. Whether heating and cooling in homes, lighting in office buildings, fuel-economy in vehicles, or industrial processes, a myriad of cost-effective energy-efficiency strategies are available to reduce energy use by 50 percent and more in many cases. Most energy technology investments and behavioral actions that influence emissions are made by these end-user communities.

Box 1. The Attribution Puzzle[74]

Socioeconomic and demographic trends clearly play important—and likely dominant--roles in the observed upward loss trends.[75] As recognized by insurers and others, migration of populations to coastal and flood-prone areas, increasing reliance on vulnerable electric power grids, and rising material wealth are among the many drivers. However, changes in the incidence and impacts of extreme weather events and sea-level rise can also be observed.[76, 77, 78, 79] Steady increases in demographic drivers also do not explain why the variability in losses has been increasing. The data also show that weather-related losses have risen much more quickly than non-weather-related losses.

An astute article in the Wall Street Journal following the losses of Hurricane Katrina points out that this "natural disaster" is indeed quite un-natural, resulting from a combination of manmade factors including rampant development in at-risk areas, mal-adaptation through the use of inadequate levies, human destruction of wetlands that protect against storm surges, and climate change.[80]

Global weather-related losses in recent years have been trending upward much faster than population, GDP, or insurance penetration, and faster than non-weather-related events.[81] The same can be seen in the case of the U.S. (Figure 1). Specific event types have increased far more quickly than the averages. For example, damages from U.S. storms grew 60-fold to US$6 billion/year between the 1950s and the 1990s.[82]

According to the latest Intergovernmental Panel on Climate Change (IPCC) assessment, climate change has played a role in rising costs of natural disasters.[83] As an illustration of the linkages, the distribution and frequency of lightning strikes is expected to change under climate change[84] and insurers indeed observe a notable increase in losses during periods of elevated temperatures.

Many human activities mask losses that would otherwise manifest. These include improved building codes, early warning systems, flood control, electric load-shedding to avoid blackouts during heatwaves, disaster preparedness and response, and land-use planning. Insurer exclusions or withdrawing from risky areas, higher deductibles, and lower limits, also produce a dampening effect on observed insured costs. As examples, inadequate building code enforcement was attributed to almost 70 percent of the costs from Hurricane Alicia and most of the homes damaged by the 2004 hurricanes were built the building code updates inspired by Hurricane Andrew.* Untangling these offsetting factors is a necessary part of any comprehensive attribution analysis and has not been dealt with satisfactorily in the literature. As leading researchers in this area observed in a discussion of flood risks:

> *"One can easily hypothesize that increasing population and urbanization in the United States has led to a commensurate increase in population at risk. Yet, one can also hypothesize that the various societal responses may have more than compensated for population growth and in fact fewer people are today at risk."*[85]

It is important not to be lulled into complacency by factors that may only temporarily mask a rise in losses.

In any event, the consequences of future climate change will be amplified by economic development and the tendency of populations to move into harm's way. Regardless of the relative weights of anthropogenic climate change and increased exposure (quantification is premature), rising uncertainty would complicate the fundamental actuarial and pricing processes that underlie well-functioning insurance markets.

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* See http://www.iii.org/media/hottopics/insurance/xxx/

Box 2. Wildfire

The Oakland/Berkeley Tunnel Fire of 1991 demonstrated the enormous damage potential of even a single fire in the wildland-urban interface. The third costliest fire in U.S. history, it resulted in $2 billion in insured losses (at 1997 prices), including the destruction of 3,400 buildings and 2,000 cars (ISO, 1997). This compares with the losses resulting from a major hurricane. Added to this were extensive losses of urban infrastructure (e.g., telecommunication, water, and transportation systems); the costs of which are borne largely by local government. The insured losses from this single fire were twice the cumulative losses experienced nationwide during the previous thirty years. Swiss Reinsurance company cited global climate change as a possible factor influencing the extent of damages caused by this and future wildfires.[86]

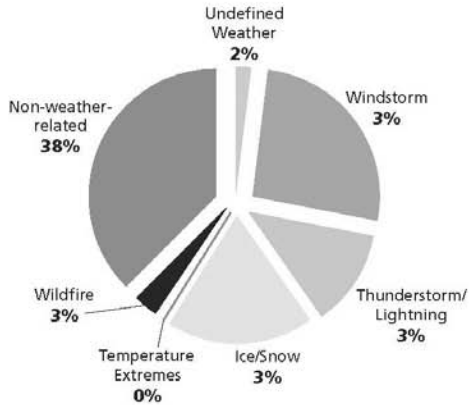
Wildfire impacts are not limited to property loss. Fires this summer in Montana are causing a 90 percent increase in hospital admissions for respiratory problems and 57 percent for cardiac problems.[87]

In areas where a high probability of wildfire loss is present, if insurance is not available through primary insurers it can be purchased in 33 states through legislatively mandated insurance pools, known as FAIR Plans. An inspection is required and generally a surcharge applies.

Because of the high brush fire potential in certain areas of California, the Insurance Services Office (ISO) with input from the California Department of Insurance (CDI) and the California FAIR Plan (CFP) acts to designate "Brush Areas". Potential brush areas are identified and inspected by ISO, and rates and surcharges established by the CFP with the approval of the CDI. Generally the CFP's "Designated Brush Areas", are limited to southern California and do not include other areas of the state exposed to wildfire. Surcharges "will vary depending on the amount of cleared space around the each structure, an area's Public Protection Classification, the type of roof, steepness of the terrain, and other considerations".[88]

Box 3. Energy and Sector Impacts

Increasingly extensive and interconnected energy systems enhance the quality of life, but also increase society's vulnerability to natural hazards.[89] Energy systems are exposed to large losses such as ruptured oil and electricity transmission systems and power plants due to permafrost melt throughout the northern latitudes. A particularly diverse set of risks exist in the electricity sector. The current U.S. baseline cost of electrical outages is $80 billion per year.[90] Under climate change, it is likely that businesses will seek increasing business-interruption coverage for such events. In addition, increasingly frequent drought conditions could result in power curtailments that cause further business interruptions in regions heavily dependent on hydroelectric power. Drought plus unacceptably higher cooling water temperatures forced curtailments or closures of nuclear and other thermal plants in France, Germany, Romania, and Croatia and price spikes in additional areas during the heat catastrophe of 2003. At the other end of the spectrum, the 1998 North American Ice Storm—likely linked to El Nino events, in turn expected to become more common under climate change, caused extensive power outages.



Causes of Electric Grid Disruptions: 51.7 Million Customers Affected (North America 1982–2002). The vast majority of outages (80-90%) occur in the electric distribution network, for which data by cause is not available. Source: North American Electric Reliability Council.

Weather disasters can damage other types of energy infrastructure. For example, massive oil sector losses were caused by Hurricane Ivan (approximately $2.5 billion, well in excess of the year's entire premium revenue for the sector)* (Miller 2004). Premiums for vulnerable oil infrastructure were projected to double after this event, and consumers faced higher prices due to the 500,000-barrel per day supply shortfall.[91] Electric utilities were also hard hit, with one utility's costs reaching $252 million.[92] The losses from Hurricane Katrina are only now beginning to emerge, with preliminary estimates that 18 oil platforms were completely lost and 12 badly damaged.† Concern has already been raised over potential withdrawing coverage for offshore oil infrastructure and associated business interruptions.[93]

* The Hurricane destroyed seven oil platforms, damaged six others as well as five drilling statements, and pipelines were buried by underwater mudslides in the Mississippi Delta.

† http://www.rigzone.com/news/article.asp?a_id=24992

Box 4. Examples of Lightning-Related Costs in the United States

Fires

- Half of wildfires in Western US (approximately 10,000 each year); $100 million in BLM suppression costs
- Over 3,000 structural and vehicle fires/year, at a cost of $35 million (1994–1999 average)
- Approximately 18% of lumberyard fires; 30% of church fires (Ohio)

Energy Sector

- About 30% of all power outages, with total costs ~$1 billion per year (1997)
- About 80% of accidents involving petroleum product storage tanks events to privately-owned plants between 1985 and 2000. Between 1990 and 2000, 346 incidents to 81 nuclear sites in US

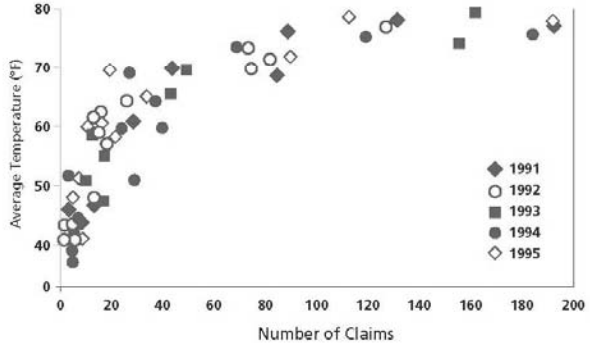
Other Types of Damages

- Worst Losses: $50 million warehouse (1997); $70 million Naval Air Rocket Test Station (1926)
- Over 50% of military aircraft weather-related in-flight mishaps
- Average $2 billion annually in airline operating costs and delays (1998)
- 101,000 desktop computer losses ($125 million) in the year 1997
- Extensive traffic signal outtages

Insurance Losses

- Approximately 5% of all insurance claims, exceeding $1 billion/year (as of 1989)
- Saint Paul Insurance Co: $340 million/year, ~4% of total losses (1992–1996 average)
- State Farm Insurance Co: 307,000 claims/year, with $332 million paid
- Factory Mutual Insurance Companies: 3–4% of all claims paid

Source: www.lightingsafety.com



U.S. Lightning-Related Insurance Company Claims Rise with Temperature: 1990–1995. Each symbold represents a lightning event in the continental U.S. Source: Hartford Steam Boiler and Inspection and Insurance Co. claims data (2000).

Box 5. The Retreat of Catastrophe Insurance: The Case of Earthquake*

- Northridge Earthquake of Jan 17th 1994 gave $15Bn market loss equivalent to 28 years of annual premiums
- Insurers demanded immediate increase in residential rates and the CA Insurance Commissioner refused
- Insurers threatened to leave the state—fear for a collapse in the mortgage and housing market
- State set up the California Earthquake Administration as alternative provider of earthquake coverage (with policies managed by insurers)
- Under pressure from reinsurers and to reduce overall risk load CEA imposed 15-percent deductibles
- CEA policies are 2x as expensive and only give half the coverage of policies issued prior to 1994
- Earthquake insurance penetration dropped from 30 percent in 1993 to 10 percent today

* Excerpted from presentation by Robert Muir-Woods, Chief Research Officer, Risk Management Solutions, June 29, 2005 "The Future of the Insurance Industry under Climate Change."

Box 6. Energy Efficiency Strategies Endorsed by the American Insurance Association*

- **Speed Limits Have Both Safety and Environmental Benefits:** Experience during the 1970s and 1980s with national speed limits of 55 mph has conclusively shown that lower speeds not only save energy and reduce greenhouse gas emissions, but also lower deaths and injuries on the highways. The abandonment of a national speed limit and a return to 65, 70, or higher mile per hour speed limits in most states was an unfortunate societal development affecting highway safety, energy usage, and greenhouse gas emissions.
- **Energy savings and loss control:** Working with several property-casualty insurers, the U.S. Department of Energy's Lawrence Berkeley National Laboratory has identified areas where energy efficiency improvements also reduce fire, explosion, or winter storm hazards. Insurers can support improvements in energy efficiency as long as they do not create new, unanticipated risks to human safety and property, particularly when energy efficiency strategies measurably improve safety and loss control.
- **Public Transportation and Other Non-Driving Alternatives:** Property-casualty insurers are generally supportive of increased investments and improvements in public transportation, and other initiatives that encourage less driving including "smart growth" strategies, HOV lanes, and pedestrian and bicycle access. These strategies reduce energy usage and promote cleaner air. For auto insurance and highway safety, they reduce congestion in urban areas and stress on drivers that leads to increased accident rates. Public transportation also helps to enhance and preserve mobility options for young and very elderly drivers that tend to have higher accident rates.
- **Telecommuting:** Increased telecommuting takes drivers off the road during the highest morning and afternoon rush hours in the most congested urban areas where accident rates and insurance costs are the highest. Telecommuting also reduces energy consumption and emissions.

* Quoted from the American Insurance Association documents.[94, 95]

Box 7. Coupled Climate and CAT Models for Better Strategic Intelligence

Disjointed modeling traditions hamper insurers' ability to assess weather-related risks and regulators' ability to safeguard both insurers and consumers. Insurers' weather-related loss models focus primarily on single catastrophic events (to the exclusion of a broader array of small-scale events that have larger aggregate impacts), are predicated on extrapolating historical trends, and largely neglect life/health impacts. In contrast, the climate change community's models are future-focused and yield longer-term results not easily applied to business decision-making or particularly abrupt climate impacts.[96] Winterstorms are an important category of relatively small-scale event that is not well captured in current catastrophe modeling tools.

The climate- and catastrophe-modeling communities operate largely in isolation. The Reinsurance Association of America has noted the opportunity and imperative for integrated assessments of climate change impacts, stating to its constituents "it is incumbent upon us to assimilate our knowledge of the natural sciences with the actuarial sciences—in our own self interest and in the public interest".[97] An effort to bridge the gap, in the case of windstorms under climate change, yielded striking results.[98] While conducted by the Association of British Insurers, the CAT modeling was performed by one of the leading US firms (AIR Worldwide, a subsidiary of the Insurance Services Office, ISO). US-based RMS also contributed to the study. Predicted losses, technical prices (risk premiums), and capital requirements under a low-emissions scenario were one-fifth to one-eighth those under a high-emissions case. The value of improved data and modeling is central, as evidenced by a shift in the industry (thanks in part to better models) toward accepting flood risks where they previously had been viewed as uninsurable.[99]

Several insurance trade organizations, plus State Farm, endorsed this idea in a letter to then Vice President Gore in 1995,[100] yet little headway has been made in this direction in the ensuing years.

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